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ABSTRACT

This is one of several study guides on contemporary problems produced by the American Association for the Advancement of Science with support of the National Science Foundation. This guide is designed to be used by teachers at the undergraduate college level and by college students intending to become teachers. The guide includes eight units: (1) Some Ideas About Learning and Teaching; (2) Individualized Instruction; (3) Contractual Learning; (4) Investigative Laboratories; (5) Community Resources; (6) Creative Problem Solving; (7) Simulated Situations; and (8) Values Clarification in Science Teaching. The units include a variety of references and some activities. (RH)

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TEST EDITION

Alternatives in Science Teaching

by Joan G. Creager

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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CONTENTS

Preface from AAAS ix

Author's Preface xiii

UNIT 1. SOME IDEAS ABOUT LEARNING AND TEACHING 4-1-1

Purpose and Objectives 4-1-1
Learning Theories 4-1-1
Behaviorism 4-1-3
Gestalt-field Theory 4-1-4
Relationships between Learning Theories and Teaching Styles 4-1-5
Principles of Learning 4-1-8
Types and Levels of Learning 4-1-9
Research in Science Teaching 4-1-12
Designing an Experiment 4-1-15
Self-Assessment 4-1-19
References 4-1-20

UNIT 2. INDIVIDUALIZED INSTRUCTION 4-2-1

Purpose and Objectives 4-2-1
Definition and Components 4-2-2
Relationship to Learning Theory 4-2-3
How to Use Individualized Instruction 4-2-5
The Role of the Teacher 4-2-6
Problems of Implementation 4-2-7
How to Prepare Instructional Objectives 4-2-9
How to Prepare a Module 4-2-12
Sample Outlines of Modules 4-2-18

UNIT 3. CONTRACTUAL LEARNING 4-3-1

Purpose and Objectives 4-3-1
The Learning Contract 4-3-2
A Contract Specifying Performance Levels 4-3-6

ALTERNATIVES IN SCIENCE TEACHING

Relationship of Contractual Learning to Learning Theory 4-3-7
How to Use Learning Contracts 4-3-7
The Role of the Teacher 4-3-9
Problems of Implementation 4-3-10
Evaluation Procedures 4-3-11
Ideas for Research 4-3-13
Self-Assessment 4-3-14
References 4-3-14

UNIT 4. INVESTIGATIVE LABORATORIES 4-4-1

Purpose and Objectives 4-4-1
The Rationale for Investigative Laboratories 4-4-2
Relationship to Learning Theory 4-4-4
How to Carry Out an Investigative Laboratory 4-4-4
Ideas from Participants in Previous Short Courses 4-4-7
The Role of the Teacher 4-4-9
Problems of Implementation 4-4-10
Evaluation of Projects 4-4-12
Research Ideas 4-4-13
Self-Assessment 4-4-14
References 4-4-15

UNIT 5. COMMUNITY RESOURCES

Purpose and Objectives 4-5-1
Kinds of Resources 4-5-2
Reasons for Using Community Resources 4-5-2
Relationship to Learning Theory 4-5-3
How to Use Community Resources 4-5-3
The Role of the Teacher 4-5-7
Problems of Implementation 4-5-7
Evaluation of Community-based Learning 4-5-8
Research Ideas 4-5-8
Self-Assessment 4-5-9
References 4-5-10

UNIT 6. CREATIVE PROBLEM SOLVING 4-6-1

Purpose and Objectives 4-6-1
Why Foster Creativity 4-6-2
Some Problems 4-6-2
Relationships to Learning Theory 4-6-3
Removing Barriers to Creativity 4-6-4
The Creative Process of Parnes 4-6-5
The Creative Process of Prince 4-6-8
Summary and Comparison of the Processes 4-6-13
Some Practice Problems 4-6-14
Ideas Contributed by Participants 4-6-15
Decision Making Processes 4-6-15
Conflict Resolution 4-6-17
A Small Group Problem Solving Model 4-6-24
The Role of the Teacher 4-6-26
Problems of Implementation 4-6-26
Evaluating the Effectiveness of Creative Problem Solving Strategies 4-6-27
Ideas for Research 4-6-27
Answers to Problems 4-6-28
Self-Assessment 4-6-29
References 4-6-30

UNIT 7. SIMULATED SITUATIONS 4-7-1

Purpose and Objectives 4-7-1
Definitions 4-7-2
Relationship to Learning Theory 4-7-2
How to Use Simulated Situations 4-7-3
Examples of Simulated Situations 4-7-5
Examples Contributed by Participants in the Chautauqua-Type Course 4-7-18
The Use of Simulated Situations in Teacher Training 4-7-19
Games 4-7-22
Bibliography of Environmental Games 4-7-22
Games with Ulterior Motives 4-7-26
The Role of the Teacher 4-7-27
Problems of Implementation 4-7-28
How to Evaluate Simulations 4-7-29
Research on the Use of Simulations 4-7-29
Self-Assessment 4-7-30
References 4-7-31

UNIT 8. VALUES CLARIFICATION IN SCIENCE TEACHING 4-8-1

Purpose and Objectives 4-8-1
The Valuing Process 4-8-2
Relationship to Learning Theory 4-8-3
How to Use Values Clarification 4-8-5
Sample Strategies 4-8-11
The Role of the Teacher 4-8-20
Problems of Implementation 4-8-21
Evaluating Values Clarification Strategies 4-8-22
Research on Values Clarification 4-8-24
Self-Assessment 4-8-25
References 4-8-26

AUTHOR'S PREFACE

Greetings! You are about to embark on an exploration of a variety of alternative instructional strategies. Because there is no one single method that serves in all situations for all students and all teachers, this study has been developed to present several kinds of alternatives. The first unit presents some ideas and theories about learning and should be considered as prerequisite for the units that follow. Each of the subsequent units deals with a particular kind of alternative and each is intended to be independent of the others.

Generally, each unit has an introductory statement of general purpose and a list of specific objectives which you might reasonably expect to achieve by completing the unit. Thus, you have an opportunity to decide whether you <u>want</u> to achieve what the unit is designed to help you achieve. Interspersed within the text and also at the end of each unit are questions to help you evaluate your own accomplishments and to stimulate your thinking about the implications of what has been presented. The final section of each unit is an annotated bibliography.

<u>Please</u> get yourself a notebook before you begin this study guide. Jot down your responses to questions included in the text and at the end of the units. Also note any parts of the text that are unclear or about which you have suggestions for improvement. Your evaluative comments on this edition will be extremely valuable. You will also find the notes may be useful for later review and reflection--some evening when you sit pondering <u>why</u> you did <u>what</u> you did that day.

This guide is designed to be used by teachers at the undergraduate college level and by college students intending to become teachers. We would also be interested in knowing how useful the guide is to teachers at other levels. Individuals representing any of these categories are invited to participate in the evaluation of this test edition. In addition to the overall evaluation form (the tear sheet immediately in front of this page), an evaluation form is included at the end of each unit. Because there are distinct differences among the units, evaluations are needed for each unit. You may mail the evaluation forms to me, or bring them to the second session of the course if you are a participant. Your efforts and your comments, particularly your criticisms, will be most appreciated.

In acknowledging the support of others toward the production of this study guide, I wish to express my appreciation first to the National Science Foundation for funding the project and second to the American Association for the Advancement of Science for giving me the opportunity to prepare this study guide.

For many of the ideas in the study guide, I am deeply indebted to the staff members of the Commission on Undergraduate Education in the Biological Sciences, particularly Darrel L. Murray, who co-edited the publication on modules with me; John W. Thornton, editor of the publication on the investigative laboratory; Donald D. Cox and Lary V. Davis, co-authors of The Case for Change, and our director, Edward J. Kormondy, who had a knack for bringing out the best in all of us. The late John D. Withers, also a CUEBS staff member and subsequently director of education for the American Institute of Biological Sciences, challenged my thinking and provided many new opportunities for me. Others who have afforded challenges and contributed ideas include staff members of the American Institute of Biological Sciences, the participants in the Chautauqua-Type Short Courses, participants in other workshops, and my

colleagues and students at Washington International College and the Alexandria Campus of Northern Virginia Community College. While I gratefully acknowledge the contributions of the many whose ideas have found their way into this study guide, I also take full responsibility for any misrepresentations or errors that may have crept in. As this is a test edition, I would appreciate having such matters called to my attention.

The camera-ready copy of this manuscript was prepared by Verne Federhen and I am most appreciative of her careful attention to detail and her conscientious concern for the appearance of the final product.

The day-in and day-out tests of my ideas about education have been generously and sincerely provided by my children. So, to Rick, Diane, Ed, and Mark, thanks a lot--a lot more than you realize.

Finally, but of greatest significance are the contributions of my husband, who has occasionally offered constructive criticisms as an educational researcher and has steadfastly offered his understanding and encouragement. Thanks, John.

Joan G. Creager

UNIT 1

SOME IDEAS ABOUT LEARNING AND TEACHING

> I did not start out to be an educational heretic, and I was inwardly astonished at the fact that when I tried honestly to review my experience, teaching seemed of such little importance and learning so vastly important. As I have continued to live with this emphasis, it no longer seems so startling as it did at the time.
>
> Rogers, Freedom to Learn, p. 151

Purpose and Objectives

The purpose of this unit is to gather together for your consideration a diverse assortment of ideas that pertain to learning and teaching. These ideas provide background for the subsequent units of this study guide, but more importantly they provide food for thought about the learning process. I hope the unit will generally encourage each user to review his own thinking about how people learn, about whether all people learn the same way, about whether one's teaching behavior matches one's beliefs about learning. More specifically, upon completion of this unit, you should be able to: (1) describe the basic characteristics of contemporary learning theories and relate them to your own teaching, (2) define learning and develop your own plans for its facilitation, (3) write a statement of your own personal learning philosophy that maximizes the congruence between theory and practice, and (4) design some experiments to adequately test the effects of one or more learning situations or strategies.

Learning Theories

The primary impetus for constructing learning theories has been to try to

learn how one learns. According to Bigge (1971), theories can be categorized in several ways: by their conception of man's[1] basic moral nature, by their conception of his actional nature, and by their method of accounting for transfer of learning. Before you read on to learn what others have said, take time to express your own thoughts. This would be a good time to start a notebook. There is no one right answer to these questions and you will evaluate your own answers as you read on. (The ultimate evaluation, of course, is the response of your students.) Do you feel that man is morally good, bad, or neutral? Is man generally a passive learner, an active learner, or an interactive learner? Is learning most likely transferred by exercising the mind, by conditioning and reinforcement, by promotion of insights and restructuring of experience or by some other means?

Some early theories about learning, as described by Bigge (1971) and by Hilgard and Bower (1966), were the mental discipline theories, the natural unfoldment theory and the apperception theory. According to the mental discipline theory man possesses an active mind substance which must be exercised or cultivated to produce or transfer learning. The theistic supporters of mental discipline believed that man was morally bad while the humanistic supporters believed that man was neutral, neither good nor bad. St. Augustine and John Calvin were early adherents to the theistic mental discipline theory, while Plato and Aristotle were early adherents to the humanistic theory. While there is still modest support for some aspects of the earlier

---

1. For clarity and simplicity masculine words will be used in a generic sense, even though such usage perpetrates subtle sexist biases in standard English usage.

theories, the contemporary theories that seem to hold the greatest promise for increasing our understanding of learning are theories of behaviorism and the Gestalt-field theories.

Behaviorism

Behaviorism includes the theories of stimulus-response learning and conditioning, with or without reinforcement. Behaviorists assume that man is morally natural, neither good nor bad, and that he is a passive or reactive learner. Although some stimuli may come from internal needs (hunger, for example), all actions are responses to stimuli. The behaviorist assumes that the surrounding physical environment will control a person's behavior and therefore his learning. The act of perception and the meaning of what is perceived are not always related in behaviorism, since perception is viewed in a mechanical way. (This is in contrast to field theory which integrates perception and meaning.) Motivation for learning is derived from innate emotions or drives or by prior conditioning and control of the environment.

In applying behaviorism to the learning process, the teacher would be concerned with controlling the environment so that the appropriate stimuli (and no inappropriate stimuli) are present and that the learners are rewarded for the desired responses. The preparation of behavioral objectives is an extension of the behaviorist theories and more will be said about objectives in Unit 2, entitled Individualized Instruction.

In any discussion of behaviorism, the question arises as to who is to control behavior and whose behavior is to be controlled. It has generally been assumed that teachers would control the behavior of students. To the extent that a student looks to a teacher's greater experience for guidance about what

he needs to know to achieve his own purposes, my personal view is that the teacher would be less than responsible if he did not provide that guidance. However, if the teacher defines the student's purposes instead of helping him achieve his own purposes, I would find that kind of control objectionable. Related to this issue of control is an article which describes how junior high level students were taught to control the behavior of their teachers and friends, simply by responding in ways that gave positive reinforcement to the kinds of behaviors the students liked (Gray, et al, 1974). This article also discusses some of the characteristics of the somewhat controversial technique of behavioral modification. Although it is beyond the scope of this study guide to consider the details of behavioral modification, references to the books of Becker, et al, (1971) and Meacham and Weisen (1969) are provided at the end of this unit.

Gestalt-Field Theory

There are several related theories which fall in this general category. For our purposes, it is more important to understand the basic ideas common to the theories than to involve ourselves in the details of the differences between them. Field theories assume that the learner is active or interactive, that is, is involved in the learning process. They also assume that purposeful behavior is based on insight. The results of learning are that the students gain new insights and perceive new organizations of information. Field theorists believe that a person's environment is psychological and that the environment consists of what is perceived. (This notion is in direct opposition to the behaviorist's viewpoint.) While the person may not perceive all that is physically present in his environment, a person's perception of an

object or event is closely related to the meaning of that object or event for the person. Thus, the field theorists argue that a person is what he is because of his interaction with his psychological environment.

Motivation emerges from the whole psychological situation. For a person to be motivated, there must be a disequilibrium in which that person wants to achieve something positive or avoid something negative. Such behavior is said to be goal oriented, and it is theorized that tension is released by proceeding toward the goal. According to Gestalt-field theory, goals are more self-set by the learner than environmentally set by the learning situation, as in behaviorism.

Teachers applying this theory will strive for personal involvement of learners and will assist them in gaining insights into the formulation and solution of problems that are real to the learners.

Relationships between Learning Theories and Teaching Styles

In discussing these relationships, Bigge creates four different images of the teacher. The conservative authoritarian teacher applies the mental discipline theory and is likely to be concerned with preserving traditional attitudes and values. He sees it as a duty to control students by telling them what to do and even what to think. The radical authoritarian may well apply behaviorism to control the environment of the students. Even though committed to change, this teacher can be as forceful in dictating what students should think and do as the conservative. The methods are more subtle. The laissez faire teacher believes in natural unfoldment and fails to provide leadership. The learning atmosphere is so unstructured that students are not challenged. A democratic facilitator of learning is likely to apply Gestalt-

field theory to help students to increase their perceptions and to gain insights by integrating facts into generalizations and principles. The atmosphere created challenges the students to define and solve problems.

In observing the triumphs and failures of some experiments in open learning systems, it would appear that teachers who are not experienced in or comfortable with the role of facilitator may adopt a laissez faire attitude and fail to provide the challenges necessary to make learning exciting. Therefore one of the greatest challenges of teaching is to offer the right mix of guidance and freedom to meet each student's needs.

Qualities of a Facilitator

The following comments are abstracted from Rogers (1969) Freedom to Learn. Rogers assumes that humans have a natural potential for learning and that significant learning takes place when the learning is perceived by the student to be relevant for his own purposes. Because learning that involves changes in one's self-perception is threatening, such learning is more easily assimilated when external threats are at a minimum. Much significant learning is acquired through doing, through the student participating responsibly in the learning process. Self-initiated learning that involves feelings and intellect is most lasting. Independence, creativity, and self-reliance are fostered by self-evaluation rather than evaluation by others. The most socially useful learning is learning the process of learning--openness to experience and capacity to change and adapt. To facilitate the kinds of learning described above, Rogers makes the following recommendations:

(1) Establish a climate of mutual trust in the learning group.

(2) Help to elicit and clarify the purposes of individuals within the group

and the purposes of the group.

(3) Rely on the desire of the student to achieve learning that is personally meaningful.

(4) Make available to the students the widest range of learning resources.

(5) Regard yourself as a flexible resource for the group.

(6) Attempt to understand and accept the intellectual content and emotional attitudes of each student. (Start where the students are to help them grow.)

(7) As an atmosphere of mutual trust becomes established, assume the role of a co-learner.

(8) Share your views with your students without imposing your will upon them.

(9) Be alert to expressions of deep or strong feelings and try to empathize and deal constructively with such feelings.

(10) Recognize and accept your own limitations. (As a facilitator, you do not need to be ready with "right answers" nor do you need to adopt practices that make you uncomfortable.)

Now that some of the basic ideas of learning theory have been presented and relationships between theories and teaching styles considered, it would be worthwhile for you, the reader, to try to describe your own teaching style. It is not the intention of this guide to impose a particular teaching style; rather it is intended that a variety of styles be considered. These pages will have served their usefulness if each reader takes the time to reflect on his own teaching style and thereby increases both his awareness of <u>what</u> he does as a teacher and his understanding of <u>why</u> he does what he does. If you are keeping a notebook (and I hope that you are), please stop reading and reflect on your way of facilitating learning. What do you do when you are teaching?

Why do you do what you do? How does your behavior compare with the ten points recommended by Rogers? (Rogers would not expect a teacher to feel that he should do everything on the list; note that the last point in the list discourages anyone from adopting behaviors that are awkward or embarrassing.)

Principles of Learning

Regardless of the theories accepted or the teaching style adopted, there are a number of general principles of learning that most psychologists would accept. Bigge (1971) has classified these principles into three categories: improving motivation, increasing efficiency, and improving retention. Factors that contribute to motivation include involvement, intrinsic motivation (completing a task because of the satisfaction inherent in the task rather than because of extrinsic or external pressures), success, and self-imposed goals. A strong demotivating factor is the situation in which there are right answers to every question. A teacher would be well advised to leave some questions unresolved and to pose some problems for which there is no one right answer. Research on the effects of testing, as reported by Bigge, indicate that except for diagnostic testing, tests produce extrinsic motivation. Students learn to pass the test rather than to satisfy their own learning goals.

The most efficient learning involves active participation by a student who has sufficient physical maturation and adequate experience to want to learn. Practice is more effective when it helps the learner to progress to more advanced stages rather than to repeat the same thing over and over. Research has shown that several short periods of practice are generally more effective than one long period.

While most of the principles of learning are supported by advocates of both behaviorism and Gestalt-field theory, the Gestaltists recommend that learning progresses best when a student tackles the largest unit he can possibly comprehend, thereby getting a better feel for the whole subject and a better understanding of the relationship of the parts to the whole. Behaviorists would be more likely to recommend small units with more frequent rewards. Unfortunately, there seems to be little research to determine which approach is better. (Readers interested in designing research in science education might note this unresolved problem.)

Retention is closely associated with the meaningfulness to the student of what is being learned. On the subject of retention, Bigge says:

> Possibly the whole point is that material that can be learned insightfully, particularly on the level of generalized insight, becomes a permanent part of one's personality structure. If teachers understood well enough the basic psychological principles involved all school learning could be of this nature.

Types and Levels of Learning

Among the ideas reviewed in preparing this study guide, there were two quite different classifications of types or levels of learning--Gagne's levels and Bigge's types. Gagne (1965) has defined learning as a change in human disposition or capability which is not simply ascribable to the process of growth. He has organized learning into a sequence of eight types, each of which is probably prerequisite to the next. The types are as follows:

Type 1 Signal learning. A subject may learn that another stimulus is coming, but the signal will never produce the response that follows the unconditioned stimulus. For example, a click may signal that a puff of air will be directed

toward the eye. The puff of air always produces an eyeblink; the click never does.

Type 2 Stimulus-response. By trial and error or by operant conditioning, a subject's response becomes bound to a stimulus. For this to happen the response must be in itself satisfying or lead to something which is satisfying.

Type 3 Chaining. This type involves a sequence or chain of stimulus-response events in which the learner has mastered each component of the chain. The learner might first learn to recognize an object, then to name it, then to describe its function.

Type 4 Verbal association. A subject might learn at least three levels of associations: (a) simple patterns of sound learned as chains, as above; (b) paired-associate learning, such as a foreign language word and its English equivalent; and (c) longer verbal sequences such as an English word and six synonyms or the equivalent word in six different languages. (There seems to be a maximum of about seven links as an upper limit of what can be learned as a single event.)

Type 5 Multiple discrimination. A subject is able to distinguish between similar shapes as would be required for selecting the appropriate key for a given lock. The ability to make multiple discriminations is thought to be built up as a chain and then a set of chains.

Type 6 Concept learning. The subject acquires the ability to respond to things or events as a class. Gagne uses the concept "edge" to illustrate how a subject might first learn to recognize a thing called an edge (type 2), then perhaps associate the thing with the name (type 4), learn to distinguish an edge from a surface or a corner (type 5) and finally develop the concept of edge (type 6).

Type 7 Principle learning. The subject learns principles by chaining concepts

in a manner similar to the increment from type 2 to type 3. For example, to understand the principle "Birds fly south in the winter", one must already have learned the concepts "birds", "fly", "south", and "winter". (It occurred to me at this writing that one might include the prepositional phrase as representing a fifth concept. "In the winter" and "winter" are different concepts. Or are they?)

Type 8 Problem solving. The subject uses the principles and all of the prerequisite types of learning to achieve some goal. Gagne relates problem solving to creativity by suggesting that sometimes a person who is working on a problem experiences a feat of generalization beyond the usual--a kind of inductive leap--a creative insight. He also suggests that many of the important discoveries are made by people who have acquired a large body of knowledge. The reward of solving one problem often creates a thirst for new knowledge so that the creative leap--more knowledge--creative leap process may be set into motion. Unit 7 will deal with problem solving and creativity in more detail.

Without necessarily assuming that one level is prerequisite to the next, Bigge (1971) defines three hierarchical levels and a fourth divergent level. Within the hierarchy, the first is the memory level in which rote learning takes place, presumably with no particular thought or purpose involved. However, the Gestaltists would argue that insight of a sort is involved whenever learning occurs. If so, such insights as occur at this level would seem to have no relationship to the material being learned. If a relationship is perceived, the learning is, by definition, of a higher level. The second is the understanding level which involves perceiving relationships or grasping the use of a fact. Learning on this level results in generalizations and the development of concepts, principles, and theories. The learner's purpose,

what has significance and meaning personally, is important in understanding-level learning. The highest level in the hierarchy is the reflection level. It includes critical examination of ideas, problem posing and problem solving. The use of genuine problems learners want to solve facilitates reflective learning.

The level which does not fit into the hierarchy was called the autonomous development level. This level involves a heightening of the learner's intuitive awareness of himself. Each learner's feelings and judgments constitute the final authority for what has meaning and significance for him. Autonomous development seems to be similar to the concept of self-actualization articulated by Maslow (1962) or the development of the fully-functioning person described by Rogers (1969). Both Maslow and Rogers look at learning from the perspective of therapists whose goal it is to help individuals to realize their full human potential. While we might argue that realization of potential is only one of the goals of science education, it would be hard to deny that it is an important and sometimes neglected one.

It is clear that there is some overlap between Gagne's types of learning and Bigge's levels of learning. Make some notes on the relationships you see. Is there some commonality between Type 8 Problem solving and autonomous development? How would you classify the kinds of learning that occur among your students?

Research in Science Teaching

Because this portion of the study guide presents a very tentative statement of the possible ways in which the methods of science can be applied to the study of teaching methods, I beg your indulgence and seek your constructive criticisms.

I feel strongly that we can discover ways to improve science education and that we can support our findings through careful applications of scientific methodologies. What is suggested here is only a modest beginning. I hope that users will contribute their best thinking to this important problem.

One of the significant results of your study of this unit so far may be that you are disturbed by the shortcomings of theories and principles of learning and the paucity of definitive research results. This section on research methods is included to encourage study guide users to evaluate various alternative teaching methods by designing and carrying out experiments with as much rigor as the real learning situation allows. Because it is expected that you, the users of this study guide, will have had both research experience in the natural or social sciences and teaching experience, it would appear that you are in a position to make significant contributions to our understanding of learning and teaching in the sciences.

Before we begin to consider research methods, we must distinguish among three kinds of problems encountered in science teaching. First, what kinds of questions are worth answering? Second, of those questions worth answering, which can be subjected to scientific inquiry? And third, of those which can be researched by scientific methodologies, what is the best method of designing, carrying out, and interpreting the research? Before reading on, take time to jot down in your notebook several questions which you would place in each of the three categories. You might also give some thought to the question of whether all questions that <u>can</u> be subjected to scientific study <u>should</u> be. List some pros and cons in your notebook.

The decision about what kinds of questions are worth answering is obviously not a scientific matter; the methods of science cannot be used to determine the

goals of science education. Two factors which can be used in deciding whether a question is worth answering are whether the findings might contribute significantly to our understanding of learning and teaching and whether the answer would clarify the goals of science education. What other factors would you use in making such decisions?

If a question meets the above criteria, it may still not be capable of being answered by the methods of science. There are at least four criteria to be considered: whether a testable hypothesis can be formulated, whether adequate control can be maintained over the learning situation, whether qualitative (or preferably, quantitative) observations can be made, and whether the results can be interpreted. Ethical and philosophical questions are, of course, excluded. Highly variable situations will pose difficult problems with respect to controls, and with respect to making consistent observations. If the results are not likely to contribute to further understanding of the learning process, then perhaps the methods of science are inappropriate.

Questions which have survived the winnowing of the first two sets of criteria are likely to be appropriate questions for research in science teaching. The remaining problems pertain to the design, implementation, and interpretation of a research problem. Four categories of variables should be considered in the design of the experiment: the attributes of the students, the conditions of the learning situation, the teaching methods, and the learning goals. In the experimental design, the independent or criterion variable is the learning goal. Variables which relate to or contribute (either positively or negatively) to the achievement of the goal are the dependent variables which include the characteristics of students, the conditions, and the teaching methods.

Designing an Experiment

The two kinds of reasoning that generally enter into scientific experimentation are deductions from the observations made and inductive inferences which contribute to the formulation of new problems. Inductive inference, according to Fisher (1966), is the only process by which essentially new knowledge is obtained. One place to start in designing an experiment is by asking a testable question and formulating by inductive inference one or more possible answers to the question. In other words, one states a hypothesis and formulates one or more possible results of testing the hypothesis. Fisher stresses the importance of forecasting all possible results of an experiment and deciding in advance what interpretation shall be placed on each result. Following his advice serves to avoid the possibility of faulty or biased interpretations which might be made if no thought is given to the matter until the conclusion of the experiment. If statistical methods and probabilities are to be used, the methods should be planned in advance. Also, the probability levels to be accepted as indicating significant differences should be decided before the experiment begins.

Statisticians use the null hypothesis--a hypothesis that states that there is no significant effect of the experimental treatment(s). The advantage of such a statement lies in the logic of scientific methodologies. Simplistically stated, a hypothesis can never be proven because there might be some subsequent observation which negates it. By testing a null hypothesis (that there is no effect), significant effects serve to disprove the hypothesis.

In addition to the careful formulation of the hypothesis to be tested and its possible interpretations, there are other precautions in experimentation. These precautions deal with the design of the experiment and the way in which it is carried out. The most important single consideration is that the

experiment should test the intended hypothesis, no more and no less. (It is not infrequent that experimenters state a hypothesis and then carry out an experiment which does not test the stated hypothesis.) Other important factors in the design of an experiment include the following. There should be provisions for estimating the error of measurement in the data collected. Appropriate procedures should be used to control for or randomize error. The experiment should be conducted with the maximum sensitivity possible under the constraints imposed. (If the constraints are so severe as to preclude the possibility of clear-cut interpretation of the results, a less ambitious, more carefully controlled experiment is called for. Fisher suggests four ways to increase the sensitivity of an experiment: (1) use more cases, (2) use more repetitions, (3) refine experimental techniques, and (4) reorganize the structure of the experimental design (by increasing the number of levels of experimental treatment, for example).

An excellent discussion of factors that affect the validity of experiments is provided by Campbell and Stanley (1963). They distinguish between factors which affect internal validity and those which affect external validity. The former might be confused with the main effects of the experimental treatment itself; the latter might appear as interactions between the experimental treatment and some other factor. The authors use the phrase, rival hypothesis, to denote that these factors might compete with the hypothesis being tested as possible explanations for the effects. By controlling for these factors in the experimental design, the factors become less plausible as rival hypotheses.

Factors which may effect the internal validity of an experiment include: (1) history, the events that happen between first and second measurements in addition to the experimental effects; (2) maturation, the processes occurring in

the respondents over time such as growing older, hungrier, more tired; (3) testing, the effects of taking a test upon the scores of a second testing; (4) instrumentation, changes in calibration, in instruments, or in observers that affect measurements obtained; (5) statistical regression, the tendency for extreme scores to change (if they change) toward the mean, which may occur when groups have been selected for their extreme scores; (6) selection biases in the choice of respondents for the control and experimental groups; (7) experimental mortality, the differential loss of respondents from the groups; and (8) interactions among two or more of these factors.

Factors which may affect the external validity include the interactive effects of testing and the experimental treatment, the interactive effects of selection procedures and the experimental treatment, effects of the experimental situation which would preclude generalizing about the effects of the experimental variable in non-experimental settings, and multiple-treatment interference such that previous treatments affect the results of new treatments in the same subjects.

Some of the more fundamental principles of experimental design discussed by Campbell and Stanley are as follows: (1) Individuals should be assigned to groups at random. Existing groups such as classes or sections should not be used as experimental groups because there are similarities in the experience of previously existing groups that interfere with the validity of an experiment. (2) Treatments should be arranged in a "double blind" fashion where possible to prevent the researcher from knowing which treatment a group has received and therefore possibly biasing his observations. (3) To control for regression, the observations on individuals at the extremes of the distribution should be examined separately. It would be expected that the low would get higher and

the high would get lower and that this regression phenomenon might obscure other differences. (4) Matched pairs should not be used as a substitute for randomization, because such matching does not control for initial differences in the experimental groups.

Three true experimental designs, as well as a number of quasi-experimental designs, were presented by the authors. Randomization of groups is essential to the true experiment and pre-and post-treatment observations are usually recommended. Of the two designs selected for presentation here, the first provides control for most of the factors that affect internal validity and the second controls also for factors that affect external validity. (R = random selection, O = observation, and X = experimental treatment)

(1) $R \rightarrow O_1 \rightarrow X \rightarrow O_2$

$R \rightarrow O_3 \rightarrow O_4$

(2) $R \rightarrow O_1 \rightarrow X \rightarrow O_2$

$R \rightarrow O_3 \longrightarrow O_4$

$R \longrightarrow X \rightarrow O_5$

$R \longrightarrow O_6$

An appropriate statistical test for the significance of differences in effects is, in the first case, a t-test performed on the difference scores: The mean of the differences, $O_2 - O_1$, is compared with the mean of the differences, $O_4 - O_3$. In the second case a two-by-two analysis of variance is one appropriate approach:

Experimental treatment X:		No	Yes
Pre-test given:	Yes	O_4	O_2
	No	O_6	O_5

Self-Assessment

Part A consists of questions or tasks of the "one right answer" variety. Answers may be found in the text of this unit. Part B consists of open-ended questions or problems which may have more than one solution. It is intended that the style of the questions should indicate the importance of learning at all levels. Factual recall may be of little importance in and of itself, but it is rare that problems can be solved without recourse to basic information and generalizations of concepts and principles. The numbers in parentheses at the end of the question or problem refer to the objectives defined at the beginning of the unit.

A-1. Describe the basic characteristics of contemporary learning theories. (1)

A-2. Define learning as you believe each of the following theorists would have defined it: (a) a behaviorist, (b) a field-theorist, (c) Gagne, and (d) Rogers. (Note: Some of these definitions are more implied than explicit in the text, so maybe the task belongs in Part B.) (2)

A-3. List at least five points that should be considered in the design of an experiment in science teaching. (4)

B-1. Which learning theory (or theories) is most clearly reflected in your teaching? (1)

B-2. Write your own definition of learning. (2)

B-3. On the basis of what is given about Gagne and about Rogers, which learning theories do you feel each of them would support? Why? (2)

B-4. Develop and write a statement describing your own plan for facilitating learning. Have you changed your views of how to facilitate learning as a result of studying this unit? If so, how. (2)

B-5. Write a statement of your own personal learning philosophy that maximizes

the congruence between theory and practice. (3)

B-6. In your judgment, which of the following questions are worth answering? Why or why not? (a) What is the most efficient teaching method for the transmission of information? (b) How can colleges develop more cost-effective methods of instruction? (c) Would the definition of instruction (in what subject? for what purpose?) enter into your decision about the value of question (b)? (d) What is the most effective method for transmission of information? (e) Does the kind of information or the attributes of the students enter into finding an answer to question (d)? (f) Should our colleges be more concerned about helping students to become aware of the social and ethical implications of the information and concepts they are taught? (g) What kinds of teaching strategies can be used to create awareness of social and ethical implications? (h) What values should you as a science teacher hold? (i) Under what circumstances should you discuss these values with your students? (4)

B-7. Of the questions posed in B-6, which can be subjected to scientific inquiry? (4)

B-8. Select at least one of the questions in B-6, state it in terms of a specific hypothesis to be tested, define a particular learning situation, and design an experiment to answer the question. (4)

B-9. Criticize your own experimental design. (4)

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American Biology Teacher, 1420 N. Street, N. W., Washington, D. C. 20005

Change, Educational Change, Inc., Box 2450, Boulder, Colorado 80302; 10 issues/$10.00

Journal of College Science Teaching, National Science Teachers Association, 1201 16th Street, N. W., Washington, D. C. 20036; 5 issues/$12.00

Physics Teacher, American Association of Physics Teachers, 335 East 45th St., New York, N. Y. 10017; 9 issues/$10.00

Psychology Today, Ziff-Davis Publishing Co., One Park Avenue, New York, N. Y. 10016; 12 issues/$12.00

Saturday Review/World, Saturday Review World, Inc., 488 Madison Ave., New York, N. Y. 10022; 24 issues/$12.00

Science, American Association for the Advancement of Science, 1515 Massachusetts Ave., N. W., Washington, D. C. 20005; 52 issues/$40.00 or by membership.

Science Education News, American Association for the Advancement of Science, Education Division, 1776 Massachusetts Ave. , N. W., Washington, D. C. 20036; free on request.

The Futurist, World Future Society, P. O. Box 19285, Twentieth Street Station, Washington, D. C.; 6 issues/$7.50

UNIT 2

INDIVIDUALIZED INSTRUCTION

> But, a tool is a tool, a passive object which achieves its purpose only when used, the degree of achievement being dependent upon the degree of the user's skill. So it is with modules, as well as with textbooks, laboratory exercises, movies, and all other accouterments of academia. Each is a tool in the hands of the teacher by means of which given ends can be reached. Tools, however, connote to me a mechanistic image, a betrayal of the creativity and humanity that is implied by the very word, teaching. Thus, I suggest that modules be regarded rather as pigments, with a constructive imagination needed to put them on canvas. Pigments can be used unmodified, and the effect is typically sharp and bold; they can be blended in virtually unlimited combinations reflecting individuality and personality. Modules must be blended by the teacher who is in this context an artist, illuminating the canvas of biology with design and sensitivity.
>
> Edward J. Kormondy, from the Preface,
> CUEBS Publication 31, The Use of
> Modules in College Biology Teaching

Purpose and Objectives

The purpose of this unit is to describe a variety of kinds of individualized instruction, to discuss how they can be used, and to describe how individual instructors might go about creating their own individualized instructional materials. Upon completion of this unit, you should be able to: (1) describe the components typically found in individualized instructional materials, (2) relate the use of individualized instruction to learning theory, (3) use individualized instruction with your students, including solving some of the problems of implementation and being able to adapt your role as teacher to the new instructional situation, (4) prepare a package of individualized instructional material, and (5) evaluate the effectiveness of individualized

4-2-2 Individualized Instruction

instruction

Definition and Components

Individualized instruction exists in a variety of forms and by an even greater variety of names: programmed instruction, computer-aided instruction, audio-tutorial, minicourses, modules, to mention only a few. Regardless of the nature or amount of hardware or software involved, let us include under the topic of individualized instruction any self-contained unit of instruction with a primary focus on a few well-defined objectives. To simplify the wording let us also select the term, module, for use in this unit to refer to individualized instruction of any kind.

The components of a module, according to Creager and Murray (1971), are as follows:

1. Statement of purpose--the general goal of the module.
2. Desirable prerequisites--what a student should already be able to do in preparation for the module.
3. Instructional objectives--the specific things a student should accomplish as a result of completing the module.
4. Diagnostic pre-test--designed to determine either readiness to begin the instruction, or already existing mastery of the objectives, or both.
5. Implementers--a term created by the editors to include all equipment and facilities needed by the user to complete the module.
6. The modular program--the instructions provided to help the student, which can be in print, on tape, on computer, or in any other available medium.
7. Related experiences--found in some modules and intended to suggest other learning activities the student is now prepared to do, because of having

completed the module.

8. Evaluative post-test--measures mastery of the specified objectives.

9. Assessment of the module--important in the development of a module and designed to determine how effective the module is, the range of amounts of time required to complete the module, and suggestions for improvements based on the experience of users.

Certainly this list is not intended to force module developers into a mold. Rather, it should serve as a kind of checklist to be used as a guide. The subject and the characteristics of the intended users should determine which of the components are included in a module.

Relationship to Learning Theory

Many modules make use of behavioristic learning theory in that they provide immediate feedback on responses, thereby reinforcing correct answers and correcting errors. Because individualized materials came into relatively wide use as a result of efforts at programmed instruction in the 1960's, such materials are generally associated with behaviorism. The idea of preparing clearly defined instructional objectives that specify an observable behavior also is an outgrowth of behaviorism.

The relationships of modules to levels of learning seem to be that, while it is far easier to prepare materials, particularly to write instructional objectives, for memory level learning, it is not impossible to write objectives that lead to mastery of concepts and principles, problem-posing, problem-solving, insightful learning, and even affective learning. The examples of simulated breeding experiments utilizing computer-aided instruction (Hyatt, et al, 1972 and Urquhart, 1973) afford evidence that self-instructional

materials can lead to mastery of higher levels of learning. More will be said about instructional objectives later in this unit.

Proponents of modules cite a number of advantages of individualized instruction: the learning sequence can be tailored to the individual student's needs and interests, student involvement is more direct than in many other modes, a student can set his own pace and spend time on material he has not already mastered. Closely related to the notion of individualization is the concept of mastery learning in which the time provided for a student to master a given set of objectives is variable. This is in contrast to the traditional specified number of lectures per semester in which the time is fixed and the level of mastery varies. Proponents of mastery learning of specified objectives argue that mastery is important and that the amount of time required for mastery is less important. Those who are skeptical of mastery learning argue that time is important; students who are slow learners will be poor performers even after they have mastered a given assignment. There remains an unresolved question about the relationship between how long it takes to learn something and how effectively or efficiently the learning is used after it has been mastered.

Critics of modules have also pointed out that instruction can become fragmented when it is individualized and packaged into small self-contained units. A Gestaltist would likely oppose such a procedure, yet it seems that a module could introduce a broad topic in a way that the student could get an overview, subsequent modules could explore subtopics, and a final module could synthesize the parts into a coherent whole.

How to Use Individualized Instruction

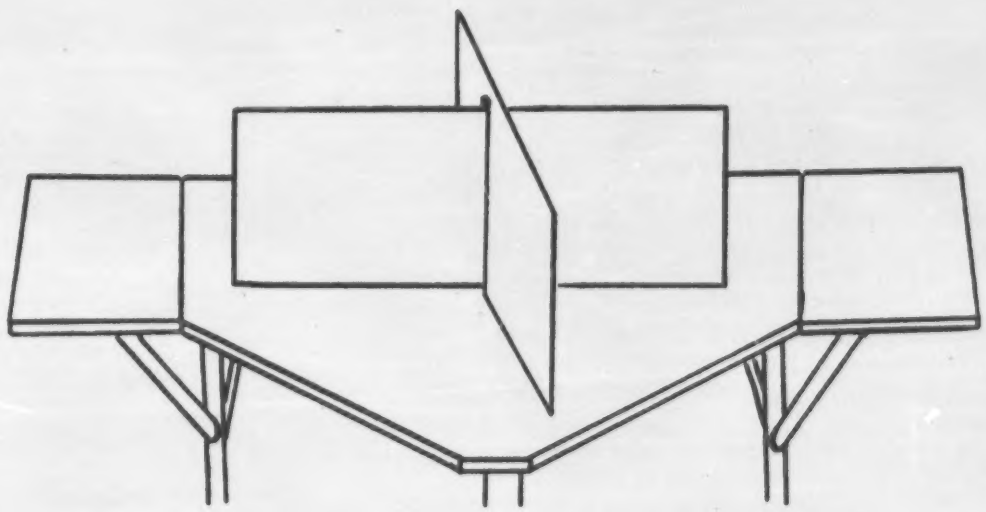
By definition, individualized instruction obviates the classroom or group mode. Since most learning situations include schedules of class meetings, ways to adapt the situations are needed. Having students work on individualized materials while you circulate in the classroom to answer individual questions is one way to proceed. An ideal use of individualized instruction is to provide for the special needs of each student. Some will have weaknesses in their background, others will need challenging advanced assignments. Some will require more time than others to complete a particular unit of instruction. Individualization can meet many of these needs.

Peer teaching can often be combined effectively with modules. Students who are the first to master a module can serve as peer teachers for other students. There is an added benefit of peer teaching; the students who serve as peer teachers learn material more thoroughly and are forced to consider new questions raised by other students. Fellow students also frequently demonstrate outstanding capability for explaining a difficult concept in terms that are understood by their classmates.

Although individualized learning often takes place in specially built, individual carrels, it is not essential to invest in such equipment. Carrels may not even be the most desirable setting for all students or for all types of learning. The simplest form of a module requires only paper and pencil. Modules intended to teach a laboratory skill or to guide field work should be portable. Various combinations of cassette tape players, illustrated instruction booklets, slides, battery-operated viewers or more sophisticated projectors, film strips, movies, and computer terminals can be devised to suit the learning purpose.

4-2-6 Individualized Instruction

If it is decided that carrels are needed, it is possible to construct a temporary carrel (see figure) from two sheets of pegboard with appropriate supports. This arrangement offers an inexpensive way to determine whether permanent carrels are needed. Also, the temporary carrels might be used in situations in which carrels are needed occasionally but laboratory tables must serve other functions. Experimental carrels have been built which accommodate two students, each with a separate set of headphones and tape player. Different information can be placed on the two tapes so the students participate in a pre-programmed interactive lesson. One slide projector presents the same visual materials to both students while the tapes present different interpretations. This system, which is being developed at the Science Education Center, University of Texas at Austin, is an unusual combination of individualization and immediate feedback through peer interaction.



The Role of the Teacher

Assuming that appropriate modules are available, individualized instruction offers the teacher an opportunity to concentrate his efforts on things only people can do. These things might include

special assistance for students with unusual interests or problems, raising thought provoking questions and encouraging students to do so, fostering creative activities, or simply demonstrating concern for students as individuals. In writing this section, I felt compelled to review Rogers' list of the qualities of a facilitator. Having done so, I am again impressed with the rightness of Rogers' views on what a teacher should be doing. How do you feel about the complementarity of the use of individualized instruction and the role of the teacher as facilitator? (Your notebook, please.) As an exercise, assume that you have access to ample modules and suitable conditions for their use: describe the ideal situation for one of your courses and your role in that situation. Remember, there is no one right answer to most of the problems posed in this study guide. Modules may be ideal for an entire course (or even a curriculum) for some students or some teachers or some situations. Modules may be suitable for parts of a course. Or they may be totally unsuited to your situation. It is your decision, but I hope you will make decisions about this and other alternative instructional strategies only after having given some imaginative thought to how you <u>might</u> use them.

Problems of Implementation

Problems fall in four general categories: space, time, equipment, and people. In implementing a program of individualized instruction, most departments have found that there are a number of trade-offs. Space for individual carrels has been perceived as a problem in many instances, but several ways to solve this problem have been suggested. In an institution where a rigid schedule of classes is used, individualization may be possible only by the use of take-home modules. If your library is willing, modules

can be checked out like books. A small beginning might also be made by setting aside a corner of a laboratory, supplying it with modules, and making it available as many hours a day as possible. If the particular modules supplied deal with the more difficult parts of a course, students are likely to use free hours between other classes to work on the modules. As students, colleagues, and administrators become convinced of the value of having some individualization of instruction, it may become easier to get approval for scheduling both time and space for it.

With respect to equipment, it can be less expensive to equip a laboratory for individualized instruction than for group instruction (where all of the students do the same thing at the same time). For example, suppose students were to learn the use of an analytic balance, how to do a titration, the use of the pH meter, and the use of several other pieces of equipment. If a module on each of the techniques is provided, a few students can make use of each kind of equipment at any given time. There is no need to have the same number of pH meters or balances as there are students in a class. The problems with equipment are likely to be related to the notion that each laboratory period should be devoted to a particular task. To reap the benefits of individualized instruction and the economies in equipment purchases, the faculty and students must become adjusted to having several things going on simultaneously in a laboratory.

People problems, if they exist, are likely to reflect honest differences of opinion about whether modules offer any advantages over the instructional mode that is currently in use. Do they? The answer to this question depends on the situation in which it is asked. What do you think about your own situation? How do you know whether or not modules will work? (Are you

making notes on your thoughts?) Is this a researchable question? What kind of experimental design would you use to determine whether the incorporation of some modules is indicated in your situation? Are there any other problems which have not been mentioned here that an instructor should be aware of before beginning to implement individualized instruction?

How to Prepare Instructional Objectives

Before beginning to prepare modules, it is important to learn to prepare instructional objectives. I have used the term, instructional objective, to deemphasize the influence of behaviorism. In the event that you are turned off by the preparation of instructional objectives, let me share with you the fact that I, too, was very skeptical of the approach when I first became acquainted with it. I am still concerned that instruction by objectives could easily become dehumanized. However, after about five years of attempting to prepare objectives, using them with students, and discussing them with colleagues, I now believe that the limitations of instructional objectives are not inherent in the objectives themselves. Rather, it is up to those of us who are concerned about humane learning and about higher levels of learning to be sure that the objectives we write lead to the intended achievements.

The preparation of instructional objectives has two distinct positive effects: (1) the student has a much better understanding of what he is expected to do and (2) the instructor is forced to state his expectations clearly--to think about what he is doing in his teaching. A serious drawback, at least in the early stages of preparing instructional objectives, is that the lower the level of learning* the easier it is to prepare clearly defined

* See page 4-1-9 for a discussion of types and levels of learning.

objectives. Many instructors, myself included, have been chagrined to discover that their first attempts at writing objectives led to the learning of clearly defined trivia. The remedy for this, I think, is not to abandon all effort to prepare objectives but rather to make a conscious effort to prepare objectives that specify the intended level of learning.

On the basis of levels of learning, instructional objectives can be divided into three major categories: (1) the basic skill and information level, (2) the higher cognitive (concept, principle, problem-solving) level, and (3) the affective level. The following examples of objectives at each level may be helpful. At the basic skill-information level: Given a blood typing kit, accurately determine your own blood type with respect to ABO and Rh antigens. At the higher cognitive level: Given readings on antigens and antibodies and the experience of typing your own blood, explain how the typing solutions work. To be acceptable, your explanation must include definitions of antigens and antibodies. At the problem solving level: Using your knowledge of respiratory systems, design a hypothetical respiratory system which is superior to those you have studied. To be acceptable your design must have three superior characteristics and an explanation for why you believe them to be superior. At the affective level: Given two alternatives in a conflict situation, choose between the two and give a reason for the choice. (Appended to this objective would be a paragraph of description for each of two conflict situations, neither of which is obviously good or bad. Two plans for gasoline rationing, two ways of making fish-meal protein palatable, etc.)

Each instructional objective has a minimum of three components: (1) the observable behavior--what the student is expected to do, (2) the conditions imposed--the equipment, facilities, time constraints, etc. to be provided, and

(3) the minimum acceptable level of performance--the procedures and criteria that will be used to determine whether the objective has been met. Several authors (Eiss and Harbeck, 1969; Mager, 1962; and Walbesser, 1971) have listed action verbs that denote observable behaviors to be used in the preparation of objectives. Before you read on, make four lists of verbs: (1) those that denote acquisition of skills and information, (2) those that indicate mastery of concepts, principles, processes (including their application to the solution of problems), (3) those that specify affective kinds of learning (including attitudes, interests, motivation, values and decisions), and (4) those that denote unobservable behaviors. Please do this before you read on; it is important that you prepare lists that are independent of the ones I have prepared. Because there is so much variation in the lists I have seen and because the observability of a behavior often depends on the ingenuity of the observer, I value the opportunity to check my judgments against yours. After you have completed your lists compare them to the lists on page 4-2-12.

Select a verb from each of the first three lists. For each verb prepare an instructional objective suitable for your students. Be sure that each objective specifies the appropriate conditions and states the level of performance expected. To test the effectiveness of the objectives you have written, prepare at least three test items for each objective. Test items need not be paper-and-pencil items; other ways of testing, such as observing activities in the laboratory, examining products of work, or engaging in discussion with a student can be used. Two important considerations in writing objectives are: first, that the test items should test for the same kind of learning specified in the objective, and second, that the learning should be generalizable. If it is difficult to prepare more than one test item, it may

Verbs and the Kinds of Behaviors They Denote

Acquisition of Skills and Information	Higher Cognitive Processes	Affective Behaviors	Unobservable Behaviors
demonstrate	organize	select	know
name	distinguish	choose	understand
describe	order	participate	appreciate
write	state a rule	challenge	grasp (the significance of)
recite	apply a rule	adopt	enjoy
identify	investigate	defend	believe
list	question	judge	have faith in
	differentiate	evaluate	comprehend
	solve	advocate	
	construct	reject	
	compare		

very well be that the learning is of a non-generalizable nature. Factual recall items are of this variety. A whole course based on factual recall or other non-generalizable behaviors would be a trivial learning experience.

Before you go on to the next section, please prepare some objectives and some test items for those objectives. You will find the experience helpful in completing the next section.

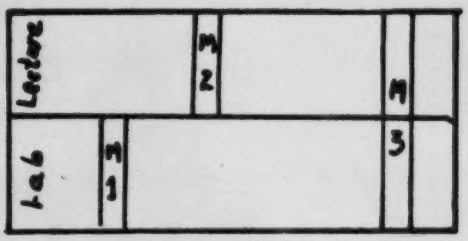
How to Prepare a Module

1. Because a module should fit into some context, start by reviewing a course or a curriculum and determine what parts of that curriculum are essential--and what items might need to be added. Think about how flexibilities can be provided for a student to make some decisions about his own learning. When you have an overview of the curriculum or course, prepare a list of the skills and facts, concepts and principles, problem-solving abilities, and affective behaviors you would expect a student to master. A flowchart for the curriculum indicating alternative pathways and various modes of learning will be helpful in

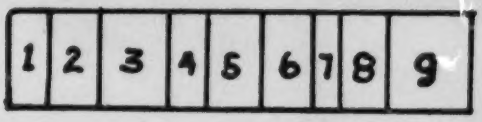
deciding what portions of the curriculum should be modularized and which should be offered in other instructional modes.

2. Divide the portion of the curriculum to be modularized into manageable sections, each of which will become a module. Your first question will probably be, "How big is a module? And as you might have guessed, there is no one set answer, only some guidelines. The smaller the module, the greater the flexibility in recombining modules into programs tailored to individual student needs. The larger the module, the greater the degree of emphasis that can be placed on interrelationships among skills and concepts and their applications and implications. There need not be a fixed size for a module; some can be longer than others. The diagram illustrates some ways to incorporate modules into learning situations.

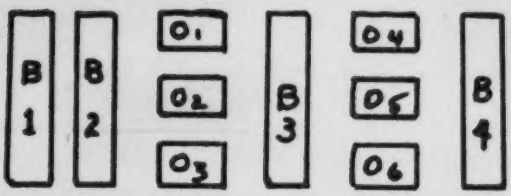
A. Modules in a traditional course:



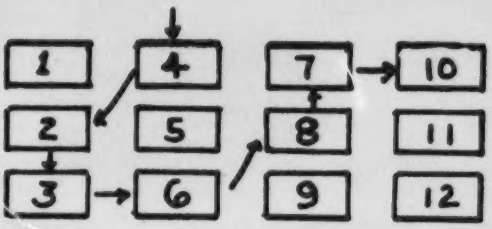
B. Linear modules where all students follow the same sequence at different rates.



C. Sequence in which students complete all of the basic modules and choose among optional modules.



D. Sequence in which students select any sequence and complete a certain number of modules.



Some module developers have assigned point value to their modules so that the longer, more difficult modules earn a larger number of points. Grades may be related to the number of points earned, so that there is a minimum number of points for a passing grade and the opportunity to make a higher grade for completing more modules and earning more points. The amount of time you anticipate that it will take a student to complete a module is also an important consideration, because there is some evidence from conversations with developers that smaller units (1-2 hours to complete) seem to be preferred to longer units by many students.

3. When a specific section of the curriculum has been allotted to a module, make a rough list of everything you want a student to accomplish. This list should have been partially completed in developing the overview of the entire curriculum in step 1. Placing each item on a small card allows for later reorganization, addition and deletion. If the module is primarily a skill module, you may want to go through performing the tasks to determine that all of the components of the tasks are included. If the module includes concepts and principles, some thought must be given to how these will be developed. If Gagne is correct about the types of learning and the sequential nature of learning, then verbal associations and multiple discriminations should precede and lay the groundwork for the understanding of concepts and principles. Some time spent reviewing your old lecture notes may be helpful. One problem with using old notes is that they generally lead to the production of very passive modules. Regardless of whether instructions are provided in writing or on tape, it is possible to incorporate more student involvement into a module than would have been in a lecture. Postlethwait, et al. (1964) offer some excellent suggestions on the production of materials for individualized instruction.

4. Check the outline (list or cards) you have prepared for completeness and organization. Add any points that have been omitted inadvertently, delete non-essentials or irrelevancies, and re-arrange the sequence of items for the benefit of a student who will be following it without depending on a teacher.

5. You may be surprised to discover that no mention has yet been made of instructional objectives. Now that the content of your module is well defined, you should look at that content and try to state it in generalizable behaviors in a set of instructional objectives. The reason for waiting until this stage of the module development to write the objectives is that most instructors are accustomed to working from procedures or notes not based on objectives. Also, from personal experience and observation of other instructors working on modules, I have found that the quality of the objectives is much better if they are written after the content is clearly defined than if they are written earlier. This procedure avoids two common pitfalls of module production. One is to define a set of objectives and then teach something else. The other is to include ungeneralizable behaviors or trivial tasks. Refer back to the section on preparing objectives as needed. Be sure that each objective includes all three components: what the student is expected to do, under what conditions, and at what performance level. It is a good idea to have in mind the criteria and procedures for constructing test items, or even to prepare some of the test items at the same time the objectives are prepared.

6. From the notes in step 4, write the modular program--the instructions you intend to provide for your students. These instructions should guide them through the mastery of each objective and should provide for a variety of activities to maximize direct involvement. If you are going to describe a piece of equipment, ask the student to go to that piece of equipment and look

at it while using your materials. Instructions are usually printed or recorded on audio-tape. Having both available makes it possible for students with sight or hearing impairment to choose a version that they can use.

7. Determine whether there are any prerequisites for the module. Have you assumed that the student has mastered certain things before he begins this module? Ask someone who is unfamiliar with the subject matter to read the modular program. You may discover that you have assumed previous knowledge without realizing it. For example, if use is made of the metric system, either the module must include appropriate information about it, or the ability to use the metric system should be listed as a prerequisite.

8. Prepare a list of all of the items of equipment and all of the supplies needed to do the tasks specified in the module. If there are solutions to be mixed, be sure directions are included for preparing them. Note any other special preparations, how long it takes to prepare them and include any other comments that might help a user or another instructor. For example, if seedlings or embryos at certain stages are needed to do the module, it should be possible to find that out before getting into the modular program.

9. If the module opens up some new opportunities for a student, these should be described under Related Experiences. If the system you are developing has required and optional modules, the options which are open upon completion of this module should be listed.

10. Procedures for the evaluation of performance need to be developed. If you prepared any test items in step 5, refer to them now along with the list of objectives and the list of prerequisites. The post-test should determine whether the student has mastered the objectives of the module at an acceptable level. The pre-test should determine either whether the student has mastered

the prerequisites or whether he has mastered the objectives or both, depending on the strategies you have decided to use. If there are prerequisites, Part A of the pre-test should determine whether they have been met. Having this test is in the best interest of the student in that he should be prepared to succeed before he begins a module. If you decide you want to offer the option of testing out of a module, Part B of the pre-test should determine whether the student has already mastered the objectives of a module. If so, it would seem that he should get credit for it and not be required to do over something he already knows. Part B of the pre-test can be an alternate form of the post-test. The cardinal rule of evaluation is to test for mastery of the objectives specified in the module. Another important rule is that objectives should require some degree of generalization. That is, a worthy objective pertaining to taxonomic classification would be to use a binomial key to classify (to a specified level) an assortment of (a certain number of) organisms. Not acceptable would be an objective that required students to reclassify the same set of organisms used in doing the module. The first requires the student to understand the principle of a binomial key; the second requires the student to memorize the examples used in the module. You are now ready to prepare the tests. While paper and pencil tests are commonly used, there is no reason why other modes cannot be used. For skills, having the student demonstrate the skill is suitable; oral quizzes are also effective.

11. When you have completed these steps, write the statement of purpose for your module. You will have all of the components except the assessment of the module.

12. Assessment can be done by having students complete a written assessment after they have completed the module. Other colleagues can provide feedback if

they have used your module with their students. A sample evaluation sheet follows on pages 4-2-19 and 4-2-20.

Sample Outlines of Modules

STREAK PLATE PREPARATION (An Example of a Skill Module)

Purpose: To develop the technique of preparing streaked cultures of bacteria on agar plates

Prerequisites: Autoclaving of media and glassware
Preparation of nutrient agar
Pouring plates, inoculating cultures

Objective: Given the necessary materials, streak bacteria from pure cultures onto agar plates with a contamination rate of less than 5%.

Pretest: 1 Demonstrate the skills listed under prerequisites.
2 Demonstrate the skill stated in the objective.

Implementers: Petri plates, nutrient agar, a pure bacterial culture, inoculating needle, bunsen burner, sterile work area

Program: 1 Prepare sterile agar plates and obtain a tube of a pure bacterial culture.
2 Using the technique you learned for inoculating cultures, flame the needle, remove the cover from the tube, dip the needle into the broth and replace the cover on the tube.
3 Lift the lid of the petri plate slightly, move the needle across the surface of the agar, and replace the lid. Repeat for 30 plates.
4 Incubate the plates at 37° C for 48 hours.
5 Have your instructor inspect the plates to determine the rate of contamination.

Related Experiences: Use skill to check water samples for coliform bacteria
Test bacterial susceptibility to various antibiotics

Posttest: Demonstrate that you can achieve the objective (Step 5 in program)

Evaluation: (Data to be collected)

MODULE EVALUATION SHEET

Name of Module _____ Name of Evaluator _____

I. Please rate the overall module on the following items. Circle your response.

a)	Did you enjoy the module?	no	Only a little	It was OK	very enjoyable
b)	Was it presented clearly?	no	Some of it	Most of it	Yes
c)	Did the parts of the module fit together well?	no	Not very well	Reasonably well	Yes
d)	Was the length of the module suitable to the task?	Too long	The right length	Too short	
e)	Did the module allow you to work at your own speed?	no	Parts of it did	Most of it did	Yes
f)	Would you like doing what you learned in a job setting?	no	Could stand it	Would be OK	Like very much

II. Please rate each of the following parts of a module wherever appropriate.

A. Written instructions: If you circle "no" or "sometimes" please explain on back of page.

1) Were the objectives of the module clearly stated? no sometimes yes

2) Were the written instructions interesting? no sometimes yes

B. Activities: Explain "no" or "sometimes" answers.

1) Were directions for activities clear? no sometimes yes

2) Did the activities help you accomplish objectives? no sometimes yes

3) Did you feel that you were actually involved in doing the module? no sometimes yes

C. Visual aids: Explain "no" and "sometimes" answers. (slides, filmstrips, film loops, transparencies)

1) Did the visual aids help to explain the topic? no sometimes yes

2) Were the visuals clearly presented? no sometimes yes

3) Were the visuals interesting? no sometimes yes

4) Was the amount of visual material appropriate? not enough about right too much

C. Audio tapes: Explain "no" and "sometimes" answers.

1) Was the voice pleasant and easy to listen to? no sometimes yes

2) Was the explanation clearly presented? no sometimes yes

3) Was the rate of speech on the tape satisfactory? too slow about right too fast

III. How much time did you spend working on the module? _____ hours _____ min.

Did you master the module? ___yes ___no At what percentage level? _____%

Was the amount of time required to do this module appropriate to the job being learned?

Needed more time About the right amount Too much time

Do you now feel competent to do the job you learned in a work situation?

No Somewhat Yes

IV. How would you change the module if you were to write it over?

V. What other questions would you ask if you were evaluating a module?

VI. Please add any other comments you feel would be helpful in improving this module.

VII. Submit with this evaluation a list of questions you had to ask about unclear points in the modul

BACTERIAL SUSCEPTIBILITY TO ANTIBIOTICS
(An Example of a Concept Module)

Purpose: To develop the concept that bacteria vary in their susceptibility to antibiotics

Prerequisites: Streak plate preparation, preparation and interpretation of graphs

Objective: Given two strains of bacteria and two antibiotics, demonstrate variability in susceptibility by preparing and interpreting graphic data.

Pretest: Interpret graphic data prepared by another student.

Implementers: Cultures of two strains of bacteria, paper discs impregnated with various concentrations of two different antibiotics, petri plates, agar, etc.

Program: (Refers to module on streaking plates, describes the use of antibiotic "discs", explains diffusion through agar and gradient established, describes a way to measure diameter of ring of inhibited growth)

Related Experiences: Isolate colonies growing nearest antibiotic discs and determine whether any are mutants no longer susceptible to antibiotics
Research some mechanisms of antibiotic action

Posttest: Interpret your graphs to relate growth suppression and antibiotic concentration.

Evaluation: (Data to be collected)

THE USE OF ANTIBIOTICS IN HUMAN DISEASE
(An Example of an Attitude Module)

Purpose: To make use of relevant scientific and sociological factors in forming an attitude about the use of antibiotics in human disease

Prerequisites: Bacterial susceptibility to antibiotics, use of periodical literature, interview techniques

Objective: Provided with library and community resources, state your attitude about the use of antibiotics, providing evidence for your position which is acceptable to your peers.

Pretest: Demonstrate mastery of prerequisites. Could be a paper and pencil test, a demonstration of skill in the laboratory, a practice simulated interview.

4-2-22 Individualized Instruction

Implementers: Bibliography, list of community information sources, ideas for interviews.

Program: 1 Do one of the following:
- A Use an interview or questionnaire to determine attitudes of medical personnel, mothers, college students, etc. on the use of antibiotics.
- B Extend laboratory studies of antibiotics to include several that are available without prescription.
- C Prepare a library research paper on antibiotics.
- D Devise a project of your own to collect information relevant to attitudes about the use of antibiotics.

2 Schedule a time to present your statement of attitude and supporting evidence to your class. Make your presentation and get reactions from the class.

Posttest: Peer and instructor evaluation of presentation

Evaluation: (Data to be collected)

Notes on Participants' Contributions

In the area of individualized instruction, there were many excellent contributions made by participants in both the 1972-73 and the 1973-74 courses. The earlier year's course was focused primarily on the development of modules; the later course dealt with essentially the same set of alternatives as are included in this study guide, but the course was focused on biology. To provide some idea of the diversity of topics developed in modular form, participants have prepared modules on electrophoresis, preparation of solutions, culturing of invertebrates, logarithms, plant morphology, how to use the library, cell structure and function, how to read and write a scientific paper, application of paper chromatography to the study of plant pigments, and several modules on patient care for nurses.

The diversity of approaches is also noteworthy. Participants have used video cassettes to illustrate the use of complex equipment, IBC Coursewriter program for computer-assisted instruction, and their own models of chromosomes

to illustrate a variety of behaviors. In some individualized courses, there are slightly different sets of objectives depending on the student's intended major, or students are asked to prepare questions for their examinations as a part of their study of the objectives, or a "hot-line" is manned by the instructor the night before the exam. Some participants combined the notion of modularized instruction with a project. For example, part of a term might be devoted to learning photographic techniques or culturing techniques and the remainder of the term devoted to using the techniques to carry out a project. A few of the participants were involved in audio-tutorial programs and several more were developing personalized (Keller plan) instruction. Some devised ways within the resources available to them personally to individualize a big class: more office hours, help sessions, study questions, informal lectures, and personal invitations to the instructor's home.

A few participants developed research projects to attempt to determine whether there were significant differences in student performance between individualized and other forms of instruction. To summarize the several studies, it was generally concluded that: (1) study guide questions keyed to instructional objectives do improve student performance, (2) many students respond favorably to optional in-depth studies as opposed to survey-type lectures, and (3) Keller-style personalized instruction where tutors are used in conjunction with self-pacing is generally advantageous. A partially contrasting view appeared in one study. Only 40% of the students surveyed indicated they would elect individualized instruction if they had a choice. Those students also felt the tutors were poorly prepared and they, personally, found it difficult to discipline themselves to keep progressing in the self-paced situation.

I have not indicated the names of the specific individuals who contributed these ideas, partly because in many cases there were several individuals who contributed similar ideas in different sections of the courses and I would have great difficulty acknowledging all contributors. However, if any readers would like further information about any of these ideas, I will gladly supply names and addresses of one or more of the contributors.

Methods of Evaluation

In addition to evaluating the effectiveness of specific modules, it is also important to conduct carefully controlled research on the effectiveness of individualized instruction. We need to know whether there are characteristics of students which are either positively or negatively correlated with performance in individualized instruction. Likewise, we might make more effective use of the talents of instructors if we could determine whether they will do particularly well in managing individualized situations. We have very little information on whether there are certain kinds of learning that should always be offered on an individualized basis or whether there are other kinds of learning that should never be offered on an individualized basis. Even within individualized situations we have only modest information on the conditions that are conducive to learning and those that are detrimental. And even if we knew more precisely the circumstances under which individualized instruction is most effective, we would still need to develop better methods of implementing the findings.

You are encouraged to accept the challenge of one of these questions or another related question and design and carry out an experiment to add to our understanding of individualized instruction. Refer to the discussion of experimental design in Unit 1 for some suggestions.

Self-Assessment

As in Unit 1, Part A concerns information from the unit and Part B is devoted to more open ended questions. Numbers in parentheses refer to the objectives of the unit.

A-1. Describe the components of a module. (1)

A-2. Select a topic from your field and describe, first, how you think a behaviorist would develop a module to teach that topic, and, second, how you think a Gestaltist would develop a module to teach the same topic. Emphasize in your answer the differences in approach of the two schools. (2)

A-3. Outline briefly how you would deal with some of the problems posed by individualized instruction and how you might adapt your teaching style to the new situation. (3)

A-4. Demonstrate to one or more of your colleagues the module you have prepared. (4)

A-5. Describe how you would evaluate your module. (5)

A-6. Propose a research plan for evaluating some aspect of individualized instruction. (5)

B-1. How would you change the list of components of a module? (1)

B-2. (a) State briefly how you stand with respect to the major learning theories. (Are you a behaviorist, a Gestaltist, or some modification or combination?) (b) Indicate how your position determines your view of individualized instruction. (2)

B-3. Describe your experience in using modules with your students, particularly, (a) the problems you encountered and how you dealt with them, (b) how you see your role as teacher, and (c) whether you feel you have adapted your style significantly to the demands of the individualized situation. (3)

B-4. How would you modify the instructions for preparing a module? What would you do differently if you were doing your module over? (4)

B-5. Carry out the plan you developed in A-5. (5)

B-6. Carry out the plan you developed in A-6. (5)

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UNIT 3

CONTRACTUAL LEARNING

> . . . Imagine a clock face with 60 minutes on it. Let the clock stand for the time men have had access to writing systems. Our clock would thus represent something like 3,000 years, and each minute on our clock 50 years. On this scale, there were no significant media changes until about nine minutes ago. At that time, the printing press came into use in Western culture. About three minutes ago, the telegraph, photograph, and locomotive arrived. Two minutes ago: the telephone, rotary press, motion pictures, automobile, airplane, and radio. One minute ago, the talking picture. Television has appeared in the last ten seconds, the computer in the last five, and communications satellites in the last second. The laser beam--perhaps the most potent medium of communication of all--appeared only a fraction of a second ago.
>
> Postman and Weingartner, Teaching as a Subversive Activity, p. 10

Purpose and Objectives

Among alternative teaching strategies, the learning contract ranks with satellites and laser beams--a new alternative that needs further exploration. Contractual learning might be thought of as an extension of individualized instruction discussed in Unit 2. However, it can be used with a group of students as well as with individuals, and generally provides more flexibility than do individualized instructional materials. The purpose of this unit is to explain some ways to use contractual learning and to present some ideas on the evaluation of learning systems in which contracts are used. Upon completing the unit, you should be able to: (1) describe the components of a learning contract, (2) describe the relationship between contractual learning and learning theory, (3) prepare and use learning contracts, (4) describe the role of the teacher in

contractual learning, (5) discuss some problems of implementation, (6) describe the components of an evaluation process, and (7) plan and carry out a research project on contractual learning and its evaluation.

The Learning Contract

A learning contract is an agreement between one or more students and a faculty member. A contract should include a learning goal and specific learning objectives. It can be written to meet the specialized needs of an individual student or a small group of students, or it can be written to describe the requirements of a course for a large number of students. If grading is a part of a learning system, the contract could specify what is required for a "D", a "C", a "B", or an "A". Regardless of which of these circumstances applies, the student(s) and the faculty member, by the terms of the contract, understand what is expected. It is an advantageous learning situation for students to have a say in the content of the contract in so far as their experience allows. The activity of stating a learning goal and determining how to accomplish it is a valid learning experience in and of itself. Beyond that, there is an important motivating factor involved in participating in defining one's own learning goals.

The learning goal is a statement of the overall purpose of the course or learning experience. The specific objectives to accomplish an overall goal should each include particular activities to be undertaken, resources to be utilized, and time limits for completion of the activities. Because this is a contract, the responsibilities of both the student(s) and the faculty member should be specified for each objective. Also the criteria and procedures to be used in evaluating the level of performance on each objective should be specified at the time the contract is negotiated. (Continued on p. 6)

Sample Contracts

Format: The following format is recommended to cover a variety of learning situations.

Learning Contract for _____
(course number and title or description of experience)

Credits_____
Dates:
Beginning_____, 19__
Ending_____, 19__

Mode of learning:
___formal course
___seminar
___independent study
___internship
___other:_____

Grading option:
___objectives specify letter grade
___pass-fail
___other:_____
Final grade:_____

Agreement between:

Student_____ phone_____ date_____
(print) (signature)
and
Faculty_____ phone_____ date_____
(signature)
(Attach statement of learning goals and learning objectives.)
(Attach statement of evaluation.)

Completion signatures:

_____date_____and_____date_____
(student) (faculty)

Natural Science Contract: The following is a sample of the learning goal and objectives for a three semester hour seminar designed as an introduction to the natural sciences to be offered in three weeks on a "total immersion" basis.

Learning Goal: Develop a working knowledge of the scientific method and at least ten scientific principles by applying the method and principles to the design of an idealized human environment.

Learning Objectives:

A. Analyze the basic physical and biological needs of human beings by listing and describing at least six components of need that should be met by an ideal environment. This objective should be completed in writing by day 3 of the seminar for discussion and evaluation by seminar participants.

4-3-4 Contractual Learning

B. Complete option 1 or 2

1. Propose a consistent system of meeting the needs derived from objective A. Tasks necessary to accomplish this will include: (a) Read and interpret scientific literature pertinent to the problem and prepare a 3000 word annotated bibliography of readings, (b) apply problem solving models (which will be demonstrated in seminar meetings) to the design of the system, (c) communicate orally to the seminar group and in writing (3000 words) the characteristics of your idealized environment, and (d) demonstrate the application of at least ten scientific principles in the operation of your environment (1 page summary appended to the paper from (c) should list and describe briefly the principles).

2. Select one factor of an idealized environment and complete items (a), (b), (c), and (d) above using a single factor." This objective should be completed by day 10 of the seminar. The faculty member and students participating in the seminar will evaluate the degree to which each item is completed satisfactorily; the creativity, humaneness, and future projection demonstrated in the written and oral report.

C. (to be done concurrently with Objective B.) Design and carry out an experiment using the scientific method to test the effects of one component of your ideal environment. Tasks to complete this objective: (a) background reading on scientific method, (b) consideration of principles of experimental design in designing your experiment, (c) careful observation during the carrying out of your experiment, and (d) thorough reporting of method, observations and conclusions. This objective should be completed by day 10. The faculty member will evaluate the written report of your experiment according to the degree to which each of the above tasks was completed satisfactorily.

D. Present a 15 minute oral report on the results of your activities in this

seminar sometime during days 11-14 of the seminar. Reports will be evaluated by student peers according to the degree to which tasks described above were accomplished and according to the tasks described in objective E.

E. Using the valuing theory (to be presented in the seminar), apply it to the idealized environments described by each other participant in the seminar. This objective is to be accomplished during days 11-14 of the seminar as the reports are given.

F. Complete an evaluation form about this learning experience on day 15 and complete all procedures pertaining to the processing of the learning contract.

Syllabus to include: Required and suggested readings on (a) scientific principles, (b) scientific method, (c) design of experiments, (d) problem solving, and (e) valuing.

Required Readings

Hypothesis, Prediction, and Implication in Biology (scientific method)
The Biosphere--A Scientific American Book (scientific principles)
Science for Society--A bibliography (a reference book)
Reprints on problem solving } to be distributed by faculty member, when needed.
Reprints on valuing }

Optional Readings

Design with Nature by McHarg
Concepts of Ecology by Kormondy
Ecology and Field Biology by Smith
Population, Resources and Environment by Ehrlich and Ehrlich
Environments in Profile by Kaill and Frey
The House We Live In by Blau and Rodenbeck
The Biological Time Bomb by Taylor
Man and the Environment by Jackson
The Environmental Handbook by DeBell
The Environment by Fortune (magazine)
Environmental Science Laboratory Manual by Strobe
Ecotactics by The Sierra Club
The Environmental Reader by Godfrey
The Year of the Whale by Scheffer
Under the Sea Wind by Carson
The Sea Around Us by Carson
The Edge of the Sea by Carson
No Deposit-No Return by Johnson
The Practice of Water Pollution Biology by U. S. Dept. of Interior
Nature Study for Conservation by Brainerd
Everyman's Guide to Ecological Living by Cailliet, Setzer and Love

4-3-6 Contractual Learning

Identifying information (name, address and phone of the student and the faculty member, the title, mode of learning, credit hours, and beginning and ending dates for the course or learning experience) should be specified on the contract. Signatures agreeing to the contract and signatures certifying completion of the terms of the contract along with a grade, if appropriate, should be included. Appended to the contract, there should be a record of work accomplished and how it was evaluated.

A Contract Specifying Performance Levels

This contract is a model for offering individualized opportunities to students in a large introductory course in one of the sciences. The overall learning goal is to master the basic concepts of the subject and at the same time to offer a variety of options for in-depth studies in selected areas. You are to fill in details for your own course. The following specific objectives are to be completed for a "C" grade:

(insert here your own minimum acceptable performance standards for your course)

To earn a grade of "B", each student must earn an additional 10 points from any combination of the following objectives. To earn a grade of "A", an additional 20 points beyond the minimum objectives must be earned.

Optional Objective A. Read any of the following articles and prepare a one page abstract. (one point per article)

(insert list of pertinent articles from journals in your field)

Optional Objective B. Attend any of the following lectures or listen to the tapes and prepare a one page abstract. (one point per lecture or tape)

(insert list of available lectures and tapes)

Optional Objective C. Design an experiment to test an hypothesis relevant to the

subject of the course. (up to 3 points as assessed by the faculty member)

Optional Objective D. Carry out the experiment and write up the results in the format of a scientific paper. (up to 17 points as assessed by the faculty member) Note: If this objective is chosen, ask your instructor for a hand-out sheet of the criteria for evaluating a research project and scientific paper. (Prepare and have available the above-mentioned hand-out; also lists of equipment and supplies available in the laboratory should be prepared.)

Before going on with this unit write at least one contract. If possible, work with one or more students to give them the opportunity to participate in writing a contract.

Relationship of Contractual Learning to Learning Theory

While a learning contract can be negotiated for virtually any type of learning, the advantages of contractual learning are to foster Gestalt-type learning. Students can participate in defining learning goals and planning how to accomplish them. The process of negotiating a contract along with the learning experiences involved in carrying it out can lead to goal-directed, insightful learning. Motivation is also strengthened by the student's participation in the planning of what is to be learned and how it is to be done. The degree of insightful learning depends largely on the objectives agreed to; however, learning that applies behaviorism--is externally controlled and prescribed--fails to reap the benefits of the process of contractual learning.

How to Use Learning Contracts

A learning contract can be prepared for virtually any mode of learning. In

a formal and traditional setting, the instructor could prepare a contract with a few options but largely devoted to what the instructor expects the students to accomplish. While this does not allow the student all of the benefits of other modes it does have the advantage of letting the students know what is expected. The act of signing a contract in which the responsibilities of both the student and the instructor are specified causes both parties to make a commitment to each other.

In the seminar mode more student participation is generally possible and student involvement in the planning of the seminar could be encouraged. The sample contract (presented a few pages back) illustrates that students can have a lot of latitude in determining how they will satisfy the objectives even though the objectives may be defined by the instructor.

A contract for independent study could be prepared by the student and reviewed by a faculty member. In this case the planning process is entirely the responsibility of the student, but the contract would not be signed unless the faculty member agreed to the terms of the contract. The fact that neither party signs a contract unless the terms are mutually agreeable prevents students from engaging in learning experiences that are not academically sound or that are not within the bounds of available resources and expertise and prevents faculty from always imposing their will on students.

An internship, which is a learning experience involving on-the-job training or some other form of practical experience, generally involves the approval of a faculty member and an individual in a practical setting. The on-the-job supervisor would accept some responsibilities for the student's training and would agree to a contract only if the experiences described in the contract were actually available. The faculty member would give approval only if the contract specifies legitimate learning that is acceptable for academic credit.

These examples of modes are probably not exhaustive of the kinds of experiences a student might propose. One of the advantages of contractual learning is that students have the freedom to prepare contracts for almost any kind of learning experience, but they must obtain faculty approval of the proposed experience before undertaking the activities.

An entire curriculum could be designed by a student and proposed in a series of learning contracts. This option allows maximum flexibility to the student. The provision that faculty approval must be obtained--that the goals of the experience must be mutually agreeable--prevents abuse of the contracting process.

Take time now to write another contract. Involve students, if possible. Perhaps you could ask some students to prepare contracts to achieve some of their goals. If feasible, work with students to actually carry out the contracts.

The Role of the Teacher

In contractual learning the role of the teacher may be as traditional as in a formal class or as non-traditional as in the case of a student who proposes his own entire curriculum in a series of contracts. Traditionally, the teacher does all of the planning, provides all of the resources, and serves as the only evaluator. If this is the case, the role of the teacher remains quite traditional--and most of the advantages of the contract have been forfeited. In contractual learning where the student is involved in the planning process, the role of the teacher is: (1) to assist in the planning process by offering realistic counsel or finding someone with the expertise to counsel the student about what learning is necessary to meet his career or personal learning goals, (2) provide resources or help the student arrange for the use of resources, (3) serve as a human resource, (4) be a co-learner with the student in some instances,

and, (5) be one of the evaluators of the student's accomplishments. If students also engage in self-evaluation, as is often the case in contractual learning, the faculty member might assist the student in developing his abilities to evaluate his own work. Whatever the responsibilities of the faculty member, they should be specified in the contract.

Problems of Implementation

One of the major problems in contractual learning is that, when students are first given the opportunity to participate in the planning of their own learning experiences, they simply do not know how to say what they want or think they need. A supporter of contractual learning would contend that the solution to this problem is not for the faculty member to usurp the responsibility for planning; rather the student should be given the opportunity to learn to plan his own future. Often a contract designed to offer the opportunity to explore many possibilities is what is needed by a student who seems not to know what he wants.

Another problem, which also reflects the student's lack of opportunities for experience, is the problem of the student who does not know how to evaluate his own work. Again opportunities should be provided to engage in self-evaluation and to compare self-evaluations with the evaluations of several other persons more experienced in a given subject area.

From the faculty member's point of view, there may be too many students doing too many different things at any one time. It takes experience in contractual learning (or any other mode that allows flexibility for the students) for a faculty member to learn to say no, not only because a proposed learning experience is not academically acceptable, but simply because the faculty member is overloaded. It is more considerate of a student to say, "Sorry, I don't have

time to supervise that contract this term," than to agree to the contract and then not fulfill the agreed-to responsibilities.

Finally, procrastination is a problem that plagues both students and faculty members. If there are no meeting times or deadlines for certain activities specified in a contract, it is all too easy to "let things ride." As long as there are courses with serious consequences for missing a deadline, the more flexible learning experiences will have second priority. It is to avoid procrastination that contracts should have built-in deadlines for both the student and the faculty member. Problems with procrastination can be minimized by participants signing contracts only if they expect to find the activities inherently rewarding; people procrastinate less on things they enjoy doing.

As you work with your students on fulfilling contracts, make some notes on problems you have encountered and how they might have been avoided.

Evaluation Procedures

The evaluation of contractual learning provides the opportunity and the challenge to design an evaluation procedure that applies to a total learning situation, including a great variety of modes of learning. The student is involved in the evaluation process along with the faculty member. One of the failings of traditional education has been that it puts the faculty member in a position of being <u>the</u> authority to pass judgment on a student's performance. While a faculty member's experience does give him a vantage point from which to evaluate a student's performance, if the student has no role in the evaluation process, he has no opportunity to learn to judge his own performance. In this system each person involved in the contract (including on-the-job supervisors, where applicable) is involved in the evaluation process. Narrative evaluations

are encouraged wherever possible. The following criteria are recommended as a check list for the preparation of each evaluation. Each individual should evaluate his own performance and that of all others involved in the learning experience. A narrative (generally no more than one page) from each participant should be appended to the completed contract.

Student Performance:

(1) Did the student complete the specific objectives? (Test results can be used here.)
(2) Did the experience contribute to the achievement of the stated learning goal?
(3) In which of the following cognitive and affective behaviors did the student demonstrate significant improvement and in which is improvement most needed?
- (a) careful judgments and critical thinking
- (b) interpretation of written materials, oral materials, non-verbal materials
- (c) oral and written communication
- (d) ability to analyze complex systems into their component parts and to perceive interactions
- (e) ability to synthesize information and ideas from various sources into coherent wholes
- (f) ability to evaluate information, project future possibilities, and make choices and commitments
- (g) ability to ask relevant questions
- (h) demonstration of creativity
- (i) demonstration of humaneness

(4) Is the student able to function as an independent learner?
(5) Did he regularly prepare for and participate in group activities?

Faculty member (and on-the-job supervisor, where applicable) performance:

(1) Did the person assist in planning?
(2) Did he facilitate student's learning, including fostering of abilities listed in item (3) above?
(3) Was he accessible to the student when needed?
(4) Did he fulfill the responsibilities specified in contract?
(5) Did he demonstrate:
- (a) ability to guide student to answers to relevant questions
- (b) the quality of creativity
- (c) the quality of humaneness

Adequacy of the learning environment:

(1) Was the environment conducive to learning?
(2) Were the necessary resources provided? (including equipment, supplies, and facilities)

If a grade is to be given on the student's performance, each participant should indicate the grade he would recommend. Also, if there were any changes in the terms of the contract during its execution, the changes should be described and appended to the contract.

After each participant has prepared a narrative evaluation, the faculty advisor should determine whether there are discrepancies that should be resolved and, if so, should meet with the student (and supervisor, if applicable). In any case, students should be able to see the evaluations, so that they can compare their self-evaluation with the other evaluation(s).

Ideas for Research

One of the first research problems that comes to mind relates to the subjective nature of the criteria for evaluating student performance which are itemized above. Although objective tests may be used to measure performance on some of the criteria, many other criteria are measurable only in subjective terms. Experiments to determine the reliability among raters on the subjective ratings would be worthwhile. Also it might be instructive to determine the reliability of the subjective measurements. Other researchable questions include the relative performance of students working on contracts with the performance of students in traditional classes not on contract, and the relative performance of groups of students accomplishing the same objectives using different modes of learning (seminar, independent study, etc.). Refer to the discussion of experimental design in Unit 1 for additional ideas about research procedures. Buros' Mental Measurements Yearbook (1972) describes a variety of tests that could be used to determine changes in performance on critical thinking, interpretation of materials, and other intellectual skills.

4-3-14 Contractual Learning

Self-Assessment

A-1. Describe the components of a learning contract. (1)

A-2. Describe the relationship between learning contracts and learning theory. (2)

A-3. Prepare and use a learning contract and describe your experiences. (3)

A-4. Describe the role of the teacher in contractual learning. (4)

A-5. Describe the problems you encountered in using learning contracts and what you did about them. (5)

A-6. Describe the components of an evaluation process for contractual learning. (6)

A-7. Plan and carry out an experiment on contractual learning. (7)

B-1. Suggest improvements on how to write a learning contract. (1)

B-2. Express your own views on the relationships between learning contracts and learning theory. (2)

B-3. Revise the contract(s) you have prepared and test them with students. Describe your results. (3)

B-4. Suggest additional components of the role of the teacher in contractual learning. (4)

B-5. Devise additional recommendations for dealing with the problems of implementing learning contracts.

B-6. Suggest improvements in the evaluation process. (6)

B-7. Write a critique of your experiment and devise a new experiment to overcome the criticisms. (7)

References

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UNIT 4

INVESTIGATIVE LABORATORIES

> . . . when we teach investigation, I think we are trying to communicate that it is
>
> an integrated web of human activities--observing questioning, generating proposals, collecting data, reducing data and making interpretations, recordings, and communicating results,
>
> which is
>
> facilitated by a characteristic set of attitudes--curiosity, openness, confidence--and skills--the ability to use symbols, logic, instruments, the library, statistics, to discriminate and measure,
>
> that it
>
> produces knowledge--observations, questions, proposals, date, interpretations--
>
> which is
>
> evaluated on the basis of its ability to reflect natural objects and predict phenomena.
>
> Thornton, The Laboratory: A Place to Investigate, p. 111

Purpose and Objectives

Investigative laboratories offer students the opportunity to design, carry out, and report on a simple scientific investigation. Other functions of the laboratory such as demonstrating phenomena and learning techniques are incorporated into the investigative laboratory--incorporated into the activities as they are needed to solve a problem. The purpose of this unit is to present some ideas about the art of investigation and about how to help students learn to do investigations. Upon completion of this unit, you should be able to: (1) describe the investigative approach, (2) explain how investigation is related to learning theory, (3) explain how to carry out an investigative laboratory, (4) describe the role of the teacher in guiding investigations, (5) discuss some of

the problems of implementating investigative laboratories, (6) describe some approaches to evaluating the process and the product of an investigation, and (7) plan and carry out a research project on the investigative laboratory.

The Rationale for Investigative Laboratories

In an investigative laboratory, students are provided the opportunity to design, carry out, and report on a simple scientific investigation. Some advantages of the investigative laboratory over the more traditional exercises are: (1) students experience what it is like to "do" science, (2) they learn how to use the scientific method, (3) they learn some methods of searching the scientific literature, (4) they learn to deal with real problems where there are not necessarily "right answers" available, and (5) they experience presenting their work to their peers in the setting of a quasi-professional meeting.

In a rapidly changing society it is not sufficient to pass along to new generations the knowledge already acquired; it is essential for students to master the processes by which new knowledge is generated. It is also important for students to develop skills in thinking critically and in making decisions based on carefully collected data. Although the investigative laboratory emphasizes process, there is good evidence from the reports of Thornton (1972) that "students who use information in the process of investigation display a remarkably high comprehension and retention of that information."

The investigative laboratory provides opportunities to offer individualized instruction which is not merely the "self-pacing of prescribed instruction", as Thornton so aptly describes some of the efforts at individualization. Truly individualized programs, according to Thornton, are self-directing, self-motivating, and self-rewarding as well as self-pacing. The investigative

laboratory can offer all of those qualities.

The kinds of learning that take place in an investigative laboratory prepare students for the kinds of thinking that research scientists use. In that sense the investigative laboratory may be said to be desirable for students majoring in science. Yet the laboratory science course that students not majoring in science usually are required to take may be the last opportunity these students will have to experience "doing" science. The understanding of the processes of science derived from even a limited investigative experience is an important component of the education of a knowledgeable citizen. And, the "doing" of science is perceived by many non-majors as a deeply rewarding experience.

A typical investigative laboratory might start with an introduction to the particular equipment and techniques students might use in their projects and with a discussion of scientific methods and experimental designs. A significant amount of individual attention (which can be provided by more advanced students) is needed when the students are designing their own individual projects and locating the equipment and materials needed. Many students demonstrate a great degree of resourcefulness in adapting household items to their scientific purposes. During the carrying out of the experiments the laboratory must be supervised, but no special week-by-week set-ups for structured laboratory exercises are required. Most successful investigative laboratories take place over a period of a quarter or a semester, but the idea can be tried on a small scale over a period of about a month.

In the investigative laboratory fewer sets of the same equipment are needed than in traditional labs; greater variety can be provided on the same budget. Most places that offer investigative laboratories have arranged for a laboratory space to be available during much of the week so that students may come in to

work on their experiments as necessary to collect appropriate data.

Relationship to Learning Theory

The investigative laboratory represents an application to Gestalt theory in that it provides a situation in which the student can develop insights, formulate, and solve problems. To the extent that the problem being investigated requires mastery of skills and techniques, the theory of behaviorism might be applied. Autonomous development enters into the investigator's personal attitude toward the process of designing and carrying out an experiment. His choice of what to do and how to do it reflects his own autonomous development. The levels of cognitive learning include memory, understanding and application of concepts and principles, and problem solving--all integrated into the process of investigation.

How to Carry Out an Investigative Laboratory

In considering whether to begin offering an investigative laboratory experience for students you should give some thought to the following factors, which are summarized from Thornton (1972): (1) The nature of investigation is difficult to convey by words; like love, it is learned by experience rather than description. This may be due, in part, to the complexity and variability of the process, or to the tendency of scientists to describe a somewhat more orderly and rational process than they actually use. (2) When the process of investigation is fragmented into several activities, the activities tend to lose some of their challenge and relevance. The whole of an investigation seems to be greater than the sum of its parts; in the context of an investigation each of the parts fits into the goal-directed whole. (3) The most difficult part of the investigative process is defining the problem. This is probably related to the fact that

defining a problem requires making choices and taking the risks involved in those choices. A student probably feels more secure doing a thorough job on a "cookbook" lab, than taking the risk of defining a problem that he might not be able to investigate adequately. (4) Finally, having students do investigations usually consumes more time and is both more frustrating and more rewarding than the instructor initially imagines.

Before an effective investigative laboratory can be offered, a survey of equipment and facilities should be made. Also students should be familiar with some basic techniques. Ask yourself: What kind of equipment will be available? What techniques have the students already learned? Which additional ones can be learned, if needed? Also, determine where and when the students will be able to work. If you are currently using one laboratory for multiple sections of a course, that space could easily be opened to the investigative laboratory. Encourage students to do some or all of their work at home or in other locations. (See Unit 5 on Community Resources.) Once physical arrangements for offering an investigative laboratory have been made, and before you are faced with a group of eager students, it is extremely important to give careful thought to how you will guide students in the investigative process.

How will students select their problems? First, it is essential to limit the possibilities to those problems you and others who will work with the students are interested in and capable of handling. This does not mean that you or your colleagues should already know the answers to research questions students will pose. It does mean that your laboratory should have the basic equipment and someone on the staff should have had some experience with the appropriate techniques. These precautions have been concerned with faculty; let us now concern ourselves with what makes a good problem from the student's point of view.

4-4-6 Investigative Laboratories

Dean (1972) lists the following characteristics:

> 1. It must be a real investigation for the student, note that the emphasis is on the words "for the student."
> 2. A good problem involves worthwhile laboratory activities.
> 3. It must be something the student can really do and do in the time available. He may well find at the end of the quarter that there are many ramifications he still wants to explore, but he should at least reach a satisfying point within the time allowed.
> 4. Above all, the problem must be interesting to the student himself.

Murray (1972b) found that students choose their topics from reading formal laboratory studies, comments in lectures, discussions with other students, and experiences in their families, and that some instructors make collections of earlier reports of investigations available to their students. He goes on to comment on the selection of problems:

> Since the selection and formulation of a problem is critical, most teachers allow several weeks for this process to take place. It is during this 3-4 week period that the student is developing his role as an investigator. At this time the teacher must provide a carefully planned mix of activities for the student invluding use of the library, laboratory experience with potentially useful techniques, group discussions and individual conferences.

A "dry lab" might be offered in which students define problems, practice posing hypotheses, and design experiments to test each of the hypotheses. Carrying out the "dry lab" as a group discussion allows all of the students to anticipate and to learn from each other. Instruction on how to use the scientific literature should be arranged. The library staff might have some valuable suggestions on how to acquaint students with the literature and might even offer an instructional program. It is important to adapt the instruction on how to use the literature to materials easily accessible to the students, because students first learning to use the literature are easily discouraged by failure

to find the references they need.

As the investigations take form and the experimental designs are developed, it is important to go over these with each student individually, first, to determine whether the design actually tests the proposed hypothesis, and second, to be sure all of the necessary supplies, equipment and facilities will be available. Be sure that you, a colleague, or an advanced student are available to answer questions or provide assistance as needed. Experience with investigative laboratories has shown that learning is greatly facilitated by having help available when it is needed. Build some check-points into the schedule for the investigative laboratory; e.g., experimental design due week 3, progress reports weeks 6 and 10, final presentations weeks 14 and 15, or some other schedule that fits your situation.

Ideas from Participants in Previous Short Courses

While it will be impossible to glean from reports all of the nuances of experiences with investigations that were presented at the short course sessions, the following list offers some practical suggestions for prospective users.

(1) Clausz (St. Andrews Presbyterian College, Laurinburg, N. C.) prepares students for investigations in cell physiology by offering four planned laboratory experiences: qualitative and quantitative determination of amino acids in a mixture, fructofuranosidase activity of yeast, fluorescence of chloroplast pigments, and sodium ion transport by frog skin.

(2) Sr. M. Cabrini Angelli (Regis College, Weston, Mass.) has devised a problem for developing students' abilities to investigate. She provides several sealed boxes containing unknown objects and asks students to formulate questions that will help them to design an experimental model of the unknown object(s).

4-4-8 Investigative Laboratories

For each question, the student is to manipulate the box in some way to gather information to answer the question. The questions, the manipulations, the answers, and the assumptions made by the student in arriving at each answer are to be written down. Students are encouraged to ask a large number of questions because the greater the number of questions the nearer the model is likely to match reality. Finally students write a description of the model and then draw a diagram of it.

(3) Enthused by the idea of the investigative laboratory at the fall session, Raverta and Rapaport (Springfield Technical Community College, Springfield, Mass.) began an investigative laboratory in the spring semester. They designed a pre-investigative questionnaire to determine the experiences their students had already had in independent investigations, their attitudes about investigation, and their familiarity with the library. The findings were used in designing the investigative laboratory.

(4) Jungck (Merrimack College, North Andover, Mass.) operates an investigative laboratory in cooperation with colleagues and senior students. Students schedule one full day per week for the laboratory but are free to specify the professor they wish to work under and the problem they want to investigate. As a result of the experience, students have obtained a clearer understanding of research and have developed confidence in their abilities, faculty have become convinced of the value of the investigative laboratory, and the senior teaching assistants reported that they learned a lot about science and also about teaching.

(5) Seeley (Queensborough Community College, Bayside, New York) introduced individual projects into a structured laboratory and stipulated that students were to rely solely on their own initiative to procure equipment. She provided

suggested topics, guidelines for preparing a report, and made herself available for individual conferences. Initial student responses were enthusiastic but final evaluations were not available at the spring session.

(6) Richardson (Tuskegee Institute, Tuskegee Institute, Alabama) administered an attitudinal questionnaire to two groups of students one of whom had voluntarily elected to participate in an investigative laboratory and the other of whom had declined to participate. Preliminary findings suggested that the participants in the investigative laboratory demonstrated strong interest and enthusiasm for that activity. However, the lesser enthusiasm of the group engaged in traditional laboratory activities may have been due to variations in student motivation prior to the laboratory experience.

Other participants scheduled laboratory topics but provided opportunities for students to decide how they would investigate the topic; or had a whole class work on the same topic with small groups each contributing a component of the investigation; or introduced a particular technique and had students carry out investigations using the technique; or cumulated data on field studies from student investigations over a period of years.

The Role of the Teacher

The primary factor in the success of an investigative laboratory is the teacher's attitude toward the students. If the teacher conveys the idea to the students that they can do an investigation and offers personal encouragement, the students' chances of success are greatly enhanced. Murray (1972a) suggests that finding a colleague in the same or a different field of science who shares an interest in teaching the art of investigation will provide a welcome companion with whom to discuss the joys and frustrations of investigative

laboratories. He also stresses the importance of students having someone to emulate; thus, another component of your role as teacher is to be an investigator yourself and to encourage upper division and graduate students to work in the laboratory. Inexperienced students should be welcome observers.

The teacher is essentially a facilitator of learning, in the sense that Rogers uses the term. (See page 4-1-6 of this study guide.) While this role may seem at first to be very demanding, Rogers would be the first to advise a teacher to adapt the role to the extent that he or she is comfortable with it. The experience of helping students to solve problems is much more rewarding to many of us than supervising a laboratory where everyone is doing the same exercise. How many iliac arteries can you enthusiastically discover in one afternoon?

Problems of Implementation

The single most frequently encountered problem is that of selecting a topic for the investigation. Students who have been accustomed to being told what to do are extremely uncomfortable in a situation where they have to make some decisions. A frequent and related problem is that students who have selected a topic often have difficulty narrowing it down to manageable proportions. The goal is to help students define a relatively simple problem and to help them design an experiment that is sharply focused on the selected problem.

Space and equipment utilization are other problems often encountered because each of the students is doing something different and may need to keep an experiment set up for several weeks. Encouraging students to keep the problem simple also helps to minimize the space and equipment problems. Another way to

deal with the space problem is to suggest ways in which projects may be carried out in dormitory rooms or at home. Finally, students and faculty could all be alert to opportunities for investigations using community resources. Some helpful suggestions are given in Unit 5.

The wear and tear on instructors is often a serious problem because it is hard to refuse to take time to talk with a student who has encountered difficulties and the difficulties sometimes seem incessant. A partial solution to this problem is to devote a significant amount of time early in the term to preparing students for investigation. At this stage, students are generally doing things in groups ("dry-labbing," learning techniques, participating in discussions, etc.) and an instructor's time can serve the needs of a number of students. Teaching loads should be calculated on the basis that time spent in laboratory is at least as valuable as time spent in lectures and discussions; if this is not the case at your institution, efforts should be made to give adequate weight to laboratory instruction. In the final analysis, the prospective teacher of investigative laboratories may have to decide whether the effort is worth the reward. For my part, I would much rather spend <u>six</u> hours dealing with interesting, varied, and challenging questions about investigations than <u>three</u> hours repeating answers to the same questions over the same exercise. Furthermore, I have never encountered a situation in which the investigative laboratory was twice as demanding as a conventional laboratory. As the laboratory is usually made accessible to students at times other than regularly scheduled periods, setting up a rotational schedule among the teachers (and teaching assistants, if available) may serve to relieve some of the pressures. Students who have taken the course only the term before are often quite helpful and perhaps can be paid or given credit for their services. You should check

insurance coverage before arranging for the laboratory to be open without a regular faculty member supervising it. If you are really concerned that you will resent putting in additional time on investigative laboratories, perhaps you should not get involved; even an investigative laboratory hardly compensates for a resentful teacher.

Because there can be many unanticipated problems in implementing an investigative laboratory, it might be advisable to mount a pilot project with one or two laboratory sections to allow you and your colleagues to test the feasibility of an investigative laboratory. It is quite likely that you will be able to adapt the ideas to your particular situation.

Evaluation of Projects

Evaluation of the final product of an investigation is one kind of evaluation; however, there should be some attention given to the quality of effort that went into the project. Narrative evaluations are probably more informative than simple letter grades. Many of the ideas about evaluation presented in Unit 3 could easily be applied to evaluating investigative projects, particularly the use of the criteria for evaluating cognitive and affective behaviors of students and the idea of both the student and the faculty member evaluating their own and each other's performance. Another list of criteria, which are used in the Northern Virginia Community College investigative laboratory, are as follows:

1. Is the problem clearly defined?
2. Is the hypothesis being tested clearly stated?
3. Given the equipment and facilities, could you repeat the experiment from the description in the paper?

4. Are the data presented clearly (a) tables and graphs easy to read, (b) metric units used, (c) calculations correct, and (d) quantitative measures used where possible in reporting data?

5. Are the conclusions justified from the results of the experiment? (adequate controls, etc.?)

6. Is there a clear distinction between observation and inference in all statements?

7. Are the conclusions related to the findings of other scientists?

8. Are adequate bibliographic references given?

9. Are scientific terms used correctly and defined if not commonly understood?

10. Is the grammar and sentence structure correct to the extent that the meaning is clear?

Finally, if a percentage or letter grade must be given, the students should have the benefit of knowing at the beginning of the term how those grades will be determined. Some kind of point system weighting the various components of the investigative process could be devised; for example, 20% of the grade could be allocated to each of the following categories: experimental design, literature review, techniques, conclusions, and preparation and presentation of report.

Research Ideas

A number of researchable questions can be formulated from the basic idea that the investigative laboratory offers a teacher the opportunity to determine what students would study if they could design their own approach to learning. Unit 3 - Contractual Learning will be helpful in this context. Also, the thesis that investigative experiences lead to the acquisition of information and the learning of concepts could be tested. It would also be interesting to know whether information and/or demonstration laboratories contribute to the ability

to design and carry out experiments. Thornton (1972) indicates that the investigative programs he studied provided affirmative answers to the following questions:

> Do Freshman and Sophomores know enough to do respectable investigation?
>
> Can an investigative laboratory be successfully offered for a class of several hundred students?
>
> Can an institution offer an investigative laboratory if its faculty's involvement is primarily in teaching rather than research?
>
> Can investigative laboratories be offered in two-year colleges and at economically impoverished liberal arts colleges?

Even though Thornton's experience led to "yes" answers to these questions, it would still be worthwhile to design carefully controlled experiments to generate more quantitative answers than are currently available.

Self-Assessment

A-1. Describe the investigative approach. (1)

A-2. Describe the relationships between investigation and learning theory. (2)

A-3. Explain how to carry out an investigative laboratory. (3)

A-4. Describe the role of the teacher in investigative laboratories. (4)

A-5. Set up a pilot program to gain some experience in investigative laboratories. (4)

A-6. Describe some of the problems encountered in the investigative laboratory and how you dealt with them. (5)

A-7. Describe the approach you used to evaluate investigative projects. (6)

A-8. Plan and carry out a research project on the investigative laboratory. (7)

B-1. Suggest modifications for the investigative approach. (1)

B-2. Add some ideas to the procedures for carrying out an investigative laboratory. (3)

B-3. Describe the role you have created for yourself as teacher in an investigative laboratory. (4)

B-4. Recommend some ways to avoid or deal with problems that might be encountered in implementing the investigative laboratory. (5)

B-5. Criticize the evaluation procedures described in the unit and recommend improvements. (6)

B-6. Criticize your research project and propose ways to improve the project; if possible, repeat the project with improvements. (7)

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4-4-16 Investigative Laboratories

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UNIT 5

COMMUNITY RESOURCES

> Society would gain if work and study were mixed throughout a lifetime, thus reducing the sense of sharply compartmentalized roles of isolated students v. workers and of youth v. isolated age. The sense of isolation would be reduced if more students were also workers and if more workers could also be students; if the ages mixed on the job and in the classroom in a more normally structured type of community; if all members of the community valued both study and work and had a better chance to understand the flow of life from youth to age. Society would be more integrated across the lines that now separate students and workers, youth and age.
>
> Carnegie Commission on Higher Education, Less Time, More Options, p. 2

Purpose and Objectives

The purpose of this unit is to encourage teachers to ferret out and make use of a host of resources for significant learning that exist within the community. Hence, the unit is not precisely concerned with an alternative mode of instruction; rather it is concerned with presenting ideas that can be used to accomplish the other alternatives through judicious use of community resources. After completing this unit, you should be able to: (1) describe the kinds of learning resources which might be found in a community, (2) relate the concept of community-based learning to learning theory, (3) describe several strategies for obtaining and using community resources, (4) describe the role of the teacher in the use of community resources, (5) describe some problems associated with the use of community resources and some ways to deal with the problems, (6) describe some techniques for evaluating community-based learning, and (7) design and carry out an experiment concerning the use of community-based resources.

4-5-2 Community Resources

Kinds of Resources

A community-based learning resource includes any person, institution, agency, or facility in which participation in its activities would be expected to result in legitimate learning. Industries that hire natural and social scientists and engineers; government agencies that hire social scientists and environmentalists; schools, hospitals, social service agencies and other non-profit organizations that hire a variety of scientists and technicians; professional societies; science-related businesses; research laboratories; and many other agencies--all of these agencies have the potential for providing opportunities for independent study and job-related learning experiences. These experiences could contribute to the clarification of a student's career goals and to the development of abilities needed to succeed in his chosen career. Possibilities for community-based learning resources are limited only by the ingenuity of the faculty members and their students.

Reasons for Using Community Resources

Two good reasons to use community resources are: (1) to increase the student's direct experience in his areas of interest beyond what is available in an academic setting and (2) to realize substantial savings to the institution in terms of instructional material and personnel costs. The uses of community resources are as numerous and diverse as the community itself. Except for very isolated areas there are usually many agencies and organizations willing to provide for group field trips or to accept individual students who are genuinely interested in learning about the agency or organization and assisting with its work.

Relationship to Learning Theory

To the extent that first hand experience and personal involvement are significant aspects of the learning experience using community resources, Gestalt type learning is involved. The development of insights into the relationships between theory and practice is fostered. Behaviorism might also be involved in the "on-the-job" learning of skills and procedures, where the setting might naturally reward success. All levels of learning can be involved from memory, through concepts and principles, to problem solving. Too, autonomous development can occur when the student becomes ego-involved in performing the tasks assigned as a part of learning in a community agency.

How to Use Community Resources

Two major varieties of community-based learning are short-term, group activities such as field trips and visiting lecturers and long-term, individualized activities such as independent study and on-the-job training.

Before community resources can be utilized, a survey of possible resources should be made and arrangements for the use of such resources should be negotiated. To begin to locate resources, think over your friends and acquaintances and whether their activities and affiliations would provide learning resources for your students. Make a list of governmental agencies and public institutions in your area, particularly libraries, museums, parks, etc. Utilities, sewage disposal plants, a city planning agency, and similar agencies provide interesting opportunities. Look through the index in the front of the Yellow Pages of the phone book. You may note such entries as agricultural consultants, agriculture-fertilizers, animal hospitals, bacteria control equipment, beer, bees, florists, food (various entries), greenhouses, hospitals, insect control,

landscape architects, . . . The list could go on. Completing such a list for your own community might be an appropriate project for your students. If you still have not found what you want, try a newspaper ad. A very successful program at McGill and Sir George Williams Universities in Montreal (Creager and Murray, 1971, p. 61) expanded its community resources by advertising for scientists--employed, semi-employed, or retired--to work with students and/or provide facilities.

After locating resources, the next step is to determine what uses can be made of the resources. An agricultural consultant might be willing to visit the class and discuss food production problems or might accept a student assistant. A class trip to a beer brewery might be arranged to improve students comprehension of the complexity of the fermentation process. A beekeeper might be willing to allow a student to make behavioral observations on the bees. Students often demonstrate great ingenuity for seeking out community resources to meet their needs and interests. A small booklet for students of all ages provides many ideas which can be adapted for use by college students (Wurman, 1972).

For field trips, ad hoc arrangements are sufficient; to arrange individualized community learning experiences requires more planning and long-range supervision. To arrange such experiences, first locate agencies; second, determine what can be learned in each. In making arrangements for students to use community resources, it is important to be assured that students will not be exploited. Arrangements should provide for the student to obtain instruction and guidance equivalent to services rendered. Sometimes it is possible to arrange for students to be paid, but the primary objective is to arrange for well supervised, quality learning experiences. As a rule of thumb a student should receive one semester hour of credit for one week's work provided that all of that work

involved essentially new experience. Equivalently, if a student works for three weeks but learns only what could have been learned in one week, that experience is worth one credit. Coupled with this guideline is the notion that once a student has learned enough to be of benefit to the agency, he should be paid for all of his efforts. Another guideline is that, while supervisors of students would not generally be paid as faculty members, they are entitled to equivalent value in services from the student for time devoted to making the student's experience a significant learning experience. Third, the specific objectives of the experience and the responsibilities of student, faculty, and supervisor should be well defined. And finally, the means by which the experience will be evaluated should be clearly specified. For suggestions about defining objectives of a community based learning experience, about describing responsibilities of student, faculty and supervisor, and about evaluating experiences, refer to Unit 3 Contractual Learning.

Community resources can also be used to advantage in investigative laboratories. Thomson (1972) cites, in addition to the use of research facilities, including the greenhouse, in other departments with the institution, the medical school facilities and hospital and health department laboratories that were used by students in their investigations.

It is a challenge to the ingenuity of any teacher to combine the use of community resources with the alternative teaching strategies presented in other units of this study guide. Some examples follow. Modules and other forms of individualized instruction could be used to prepare students for on-the-job experiences; conversely field trips and guest speakers could be used to stimulate interest in individualized learning activities. Contractual arrangements are ideal for recording responsibilities agreed to in community situations. The

utilization of community resources can greatly expand the types of investigations from which a student may choose. Also, an overworked faculty member can be relieved of some of the burden of overseeing and guiding the investigations. A few instances of arrangements with persons in the community have resulted in the student's advisor being amazingly pleased with the opportunity to work with students. Some community-based situations require the student to solve problems. Activities in the classroom to develop his problem solving capabilities complement the community-based experiences. Simulated situations exemplify the only way--at least the only way I know of--for a student to get a feel beforehand for what a community-based experience might be like. Teachers are encouraged to create simulations that will help students know what to expect in a community-based experience. Finally, values clarification is furthered by direct experience outside the academic setting. Choosing from alternatives and affirming belief publicly is much easier within the shelter of the classroom than is acting repeated on one's professed beliefs in a "real-world" setting.

One final, and somewhat tangential, example of community-based learning is educational life experience for which many colleges are beginning to offer academic credit. Many students, particularly working adults attending college part-time, have accumulated a variety of learning experiences outside formal courses. It seems likely that increased use of community-based learning for matriculated students will tend to encourage increased acceptance of educational life experiences for academic credit. In my experience working with students in planning what they will present to their institution in application for life experience credits, I have been amazed at the reluctance of students to include non-classroom experiences in their portfolios. Students simply have great difficulty recognizing experiences as significant learning experiences unless

they occurred in an academic setting.

The Role of the Teacher

In using community resources the teacher has typically made arrangements for field trips, briefed students before the trip and discussed the significance of observations after the trip. When students use community resources for independent study and job related experiences, the role of the teacher becomes that of planning with the student, assisting with arrangements, overseeing the experience to assure that the objectives are met and the responsibilities fulfilled, and participating in the evaluation of the experience.

The teacher should also concern himself with the problem of whether or not a student shall be paid for his efforts and how much academic credit the student should receive. Within the guidelines given in the "How to Use" section, it is the responsibility of the faculty member to assure that neither the student nor the supervisor or the agency are exploited. The relationship should be mutually beneficial; the faculty member has the role of the intermediary to consider and attempt to resolve any problems that arise in the relationship between the student and the supervisor.

Problems of Implementation

The time demands of planning, arranging and overseeing community learning experiences will seem unreasonable unless you consider the time usually spent in setting up and supervising regular laboratories, preparing and delivering lectures in which all students regardless of their individuality receive the same treatment. If your college has a "January term" or some similar relatively unstructured period of time, that is an ideal time to try individualized programs

using community resources. Since the investigative laboratory and the use of community resources are complementary approaches and present some of the same problems in implementation, you might want to try combining these two approaches. Never underestimate the students' capacities for making arrangements for the resources they need!

Another category of problems pertains to the documentation and certification of community-based experiences as legitimate learning. Experiences in community agencies should be planned so that the relationship of the experiences to the student's academic program is specific and unquestionably of academic value. At the undergraduate level, it will be necessary to present evidence to graduate schools, professional schools, or prospective employers that the student's experiences are at least as valuable, if not more so, that comparable course offerings.

Evaluation of Community-based Learning

The primary criterion in evaluation is "Can the student do the job which the experience was intended to teach? Because of the similarity of the evaluation of contractual learning and the evaluation of community-based learning, the information on evaluation provided in Unit 3 Contractual Learning is recommended for use here.

Research Ideas

A number of researchable questions can be posed as variations on the basic question of whether community-based learning activities are of as good quality as conventional learning activities. A careful study of what kinds of learning are most likely to be fostered in community settings and what kinds are most

likely to be fostered in other settings would be of great value. The whole question of evaluation of community-based learning is also open to well-controlled and carefully designed research. Finally, procedures for evaluation of educational life experience are needed. Refer to the information on research design in Unit 1, for ideas on how to plan and execute such studies.

Self-Assessment

A-1. Describe the kinds of learning resources that might be found in a community and prepare a list of those available in your community. (1)

A-2. Describe the relationships between the use of community resources and learning theory. (2)

A-3. Describe the strategies you actually used for obtaining and using community resources. (3)

A-4. Describe your experiences in the role of teacher in the use of community resources. (4)

A-5. List the problems in implementation you encountered and how you dealt with them. (5)

A-6. Describe how you evaluated your students' community-based learning. (6)

A-7. Describe the experiment you carried out concerning the use of community resources. (7)

B-1. Suggest other kinds of community resources beside those mentioned in this unit. (1)

B-2. Propose a learning theory that accounts for the learning that takes place through the use of community resources. (2)

B-3. Suggest improvements on the strategies described in this unit for developing and using community resources. (3)

B-4. Prepare a critique of the role of the teacher presented here and suggest improvements. (4)

B-5. Propose procedures for avoiding the problems you encountered in implementing the use of community resources. (5)

B-6. Suggest new ways of evaluating community-based learning. (6)

B-7. Criticize your experiment and repeat it in an improved form. (7)

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UNIT 6

CREATIVE PROBLEM SOLVING

> . . . Groups of young people might be invited to ransack their minds for previously unexamined approaches to urban sanitation, crowding, ethnic conflict, care of the aged, or a thousand other present and future problems.
>
> In any such effort, the overwhelming majority of ideas put forward will, of course, be absurd, funny or technically impossible. Yet the essence of creativity is a willingness to play the fool, to toy with the absurd, only later submitting the stream of ideas to harsh critical judgment.
>
> Toffler, Future Shock, p. 411

Purpose and Objectives

The purpose of this unit is to invite you and your students to ransack your minds for new approaches to any of the myriad contemporary and future problems of our society. The sample problems and exercises are designed to remove barriers to creativity, foster the generation of creative ideas, sharpen decision making skill, and develop methods for dealing with conflict. Upon completing this unit, you should be able to: (1) relate creative problem solving to learning theory, (2) assist your students in removing barriers to their creativity, (3) elicit creative ideas from your students, (4) help students to apply decision making skills to creating optimum solutions to problems, (5) apply techniques of conflict resolution in your teaching, (6) describe the role of the teacher in the creative problem solving processes, (7) discuss some of the problems of implementing these techniques, (8) evaluate the effectiveness of the techniques as teaching alternatives, (9) pose at least three researchable questions about teaching strategies to foster problem solving, and (10) carry out an experiment to answer one of the questions posed.

Why Foster Creativity

It is not enough for teachers to be creative in what they do with their subject; methods are needed to help students develop their own creativity along with their knowledge. Whitehead said, in The Aims of Education (1929), "Fools act on imagination without knowledge; pedants act on knowledge without imagination. The task of a university is to weld together imagination and experience."

Some Problems

One of the questions we will eventually consider is how do people go about solving problems. To gather data on that question, your reflections on how you solve problems will be helpful. Please get out your notebook and divide a page into three columns. Head the columns: Problem, Thoughts, Feelings. In the first column write specific data pertaining to the solution of the problem; in the second column write the thoughts that pass through your mind as you work on the problem; in the third column, describe your feelings as you work on the problem. Please make these notes; it is very important to get some data on how people solve problems, where insights occur, etc.

Try the following problems:

(1) Without lifting your pencil from the paper draw four straight connected lines which will pass through all nine dots, but through each dot only once. (Copy the pattern of dots shown at the right into your notebook. Make as many sets of dots in your notebook as you need to solve the problem.)

(2) Using six whole match sticks, build exactly (no more than, no less than) four equilateral triangles with each side equal to the length of one match stick.

(3) Assume that you have a paper bag containing two red and eight white poker chips. On each cycle of the game, you draw out chips until you get a red one, without replacing any of the white chips you draw. (If, for example, on the first draw you get a white chip, you lay it aside and draw again. If on the second draw you get a white chip, you also lay it aside and draw again. If you get a red chip, you score that a red chip was drawn on the second draw, replace the white chip from the first draw and begin another cycle of the game.) The problem is to determine on which draw in a cycle you are most likely to draw the first red chip. (Problem suggested by T. J. W. Baker, Wesleyan University.)

Relationships to Learning Theory

Under the topic, "When is a problem a problem?", Bigge (1971) says:

> Too many teachers who have attempted a problems approach to teaching have not adequately understood the psychology of learning as it relates to problem-centered study. Older psychologies--mental discipline, apperception, behaviorism--had little to say about problem-centered study. Nor have neobehaviorists, with their more sophisticated S-R conditioning theories, contributed much understanding of reflective teaching.

For a learning problem to involve the learner, according to Bigge, it must belong to the learner, that is, it cannot be somebody else's problem. The question then becomes a matter of how to involve a student in a significant problem. The student, who is the prospective problem solver, must discover inconsistencies between competing ideas, attitudes or values. Some techniques a teacher may use are: (1) the introduction of disturbing data, (2) permitting students to make mistakes, and (3) converting societal problems to personal problems. Once a student has been brought to recognize a problem, the next step is the formulation and testing of hypotheses. From this point Bigge's discussion of problem solving is an application of the basic principles of scientific methodology.

4-6-4 Creative Problem Solving

It should be obvious from this discussion that problem solving is much more allied to Gestalt-field theory than to behaviorism. Problem solving involves greater application of the higher levels of learning than of the lower, memory level; it can involve autonomous development to the extent that the student identifies the problem as his and derives self-fulfillment from dealing with the problem.

Removing Barriers to Creativity

The first technique we need to explore is how to free students to be creative. Parnes (1967a and b) offers some suggestions about how to remove barriers to creativity. One of the major inhibitors of creativity is unconscious conformity. To encourage people to engage in imaginative, creative thinking, they must become conscious of their own blind conformity. Although there is some research evidence for hereditary and past environmental factors affecting creative potential, that potential can be enhanced. We can help students to see themselves as potentially creative persons and we can create an environment that encourages creativity. Such an environment might include learning programs deliberately designed to develop the creative qualities. These deliberate actions fall in two categories: (1) enriching a person's experience and (2) eliminating or decreasing blocks to creative thinking. Enrichment would include not only new knowledge but new associations between what is consciously known and what is subconsciously known. Blocks can be decreased or removed by creating an accepting environment, where external evaluation is absent and members of the group can empathize with each other. Breaking or exhausting conformist or habitual responses can also decrease blocks, as can forcing the invention of new relationships. To try to overcome some of your own barriers to creativity try the following problems.

(1) Name five uses besides the intended purpose for a penny, . . . for a telephone book.

(2) Write a classified ad to sell one of the following used items: plastic bottles, pop-top cans, glass jars.

(3) Design an experiment using any of the above mentioned items and any of the following: polluted water, wire, thread spools, a rubber ball.

(4) Improve the design of a toothbrush.

(5) Recall the last time you had to stand in line and design a way to avoid waiting.

Please complete the problems before you read on. You will need your responses to answer the next questions.

(1) To what extent have you broken away from blind conformity in your responses?

(2) Have you formed any new associations in your mind as a result of working on the problems?

(3) Do you think you could have given more creative responses if your background of experience were richer and more diverse?

Some qualities of the creative individual according to Steiner as reported by Parnes (1967a) include: conceptual fluency, originality, ability to make independent judgments, ability to suspend judgment, non-authoritarian behavior, experiencing of a rich fantasy life and at the same time demonstrating strong reality orientation. Let us now look at some ways to nurture these qualities.

The Creative Process of Parnes

Generating Ideas: Got a problem? A big problem, a little problem, a petty annoyance, something about money, friends, work, leisure, civic activities, family? an experimental design? Any problem will do. Generating ideas for

creative problem solving without a problem to solve seems pointless. (The thought reminds me of a criticism of conventional education--that it gives student answers to so many questions they haven't asked.)

At the top of a page in your notebook, write a brief statement of your problem. It can be a single phrase. Now force yourself to list at least ten ideas about how to solve the problem. Some of those ideas will seem ridiculous; write them down anyway! Please make your list before you read on.

Perhaps you are wondering why you are asked to do this if you are a teacher and this study guide is intended to help you teach. The main reason is that, if these exercises do foster creativity, you will become a more creative teacher. Also, you will be better prepared to guide your students in some of the activities after you have done them yourself.

Now, to get on with the exercise, pick up a book, any book will do. Open it at random to any page and select a word from each of the facing pages. Close your eyes and point to a word on each page. Write the two words in your notebook and think of some way to relate the two words. For example, a pair of words selected were "momentum" and "atmosphere". I associated them in the sentence, "Wind is momentum in the atmosphere." Or, irregularities" and "step" were associated in, "Don't step on irregularities in the sidewalk."

Apply this technique to your original problem, by selecting word pairs at random from a book or from the list of ten ideas. Generate ten more ideas about how to solve your problem.

Parnes (1967a), whose ideas are the basis for the above exercises, describes the following results of an idea generating session.

> A group of supervisors were trying to think up ideas as to how to keep plant workers from wasting time reading the newspapers in which they were packing their company's products. The first idea that came to someone's mind was to use foreign-language newspapers as stuffing material. The next idea was to hire illiterate workers for these jobs. A third idea was to blindfold the workers. A fourth idea was to hire blind workers for the job. The last idea was considered quite workable and advantageous.

The basic rules to remember in the idea generating stage of the creative process are that no idea is to be criticized, the more ideas the better, and combinations of ideas are to be encouraged.

It should be noted that while this guide has been written for an individual, it is probably more effective when used in a group.

Evaluating Ideas: List all of the criteria you can for evaluating solutions to the problem. Defer judgment on which are the best criteria until you have listed every criteria, no matter how unusable it seems. Try to combine ideas to see if you can improve the criteria. Finally, select three or four of the most appropriate criteria. Then rank the ideas you have generated according to how well they meet your criteria. A table with criteria in columns across the top and ideas down the left side makes a useful way to tabulate ratings. From the ratings of the various ideas put together a tentative solution. That solution may very well be a combination of the best of several ideas.

Implementing a Solution: Once you have a tentative solution, the next step is to try to find out what all is wrong with it. Try to anticipate what might go wrong if you were to implement the solution. For example, what might be some of the problems associated with hiring blind people to pack products? Are there safety hazards? What changes in the plant will be needed to assist blind people? Will it be possible to find blind people to employ? Parnes suggests a checklist of: Who? What? Where? When? Why? How? to generate ideas about trouble spots.

The Creative Process of Prince

The technique called Synectics, (Prince, 1970) involves an orderly sequence of events which begins with defining a problem--most any kind of problem. In the teaching of science such problems might include designing an experiment, devising a variety of ways to present a concept or teach a skill, exploring solutions to contemporary problems, or discovering approaches to problems in interpersonal relationships. There are only two rules of operation but these must be adhered to without exception: (1) all participants including the leader must listen intently to every other member's ideas; and (2) critical judgment about ideas must be suspended and some good must be found in every idea that is expressed.

Synectics is a group process and the ideal group size is about seven. An easel with large sheets of paper or several blackboards are needed.

Here is a sample problem: how to remove some of the inhibiting factors that keep teachers from being concerned with the future. Given this problem, the session leader would ask his group of six to eight participants to list any immediate solutions that enter their heads. As these solutions are described, the leader writes the main ideas on a large easel. Throughout the session, the leader records ideas and fastens the pages from the easel on the wall in view of the group.

There are two reasons for eliciting immediate solutions, first they might be quite as good as later ones, and second, if the participants do not get a chance to express them, holding them in mind tends to inhibit their ability to think of anything else.

Participants are then asked to express their view of the ideal solution to the problem. Wishful thinking, even unrealistic and impossible goals are to be

encouraged at this point. The leader reviews the goals and the group agrees on the one they want to work toward. That goal may be a combination of two or more of the original goals.

Some immediate solutions given in an actual situation were: make change desirable; provide sensitivity training for teachers, students, parents, and administrators; and introduce a student voucher system whereby students can reward teachers. Some of the goals mentioned were: dispense with the bureaucracy; make education and pre-teaching experience of teachers more future-oriented; provide more effective upward communication; and minimize the threat of change. In the example, minimizing the threat of change was the goal selected for further consideration.

After the goal is defined, the leader tells the participants to put the problem out of mind and go on an excursion. The purpose of the excursion is to get the group thinking about things as far removed from the problem as possible. The rationale is that much of the experience stored in the brain is not consciously available and that associations between previous experience and the problem at hand would not likely occur if the group simply thought about the problem. There are three kinds of excursions and each may be used several times during one problem solving session. The three types are examples, book titles, and personal analogies. Each component of the excursion is connected to what has gone before by starting a new step with a word selected from the step just completed. Each time a linking word is chosen it is chosen partly because of its apparent unrelatedness to the original problem, partly because of the leader's judgment that it is an appropriate word to begin the next excursion. Examples: The leader selects an object or phenomenon and asks for examples. If the context from which the example came was from the physical sciences, he might

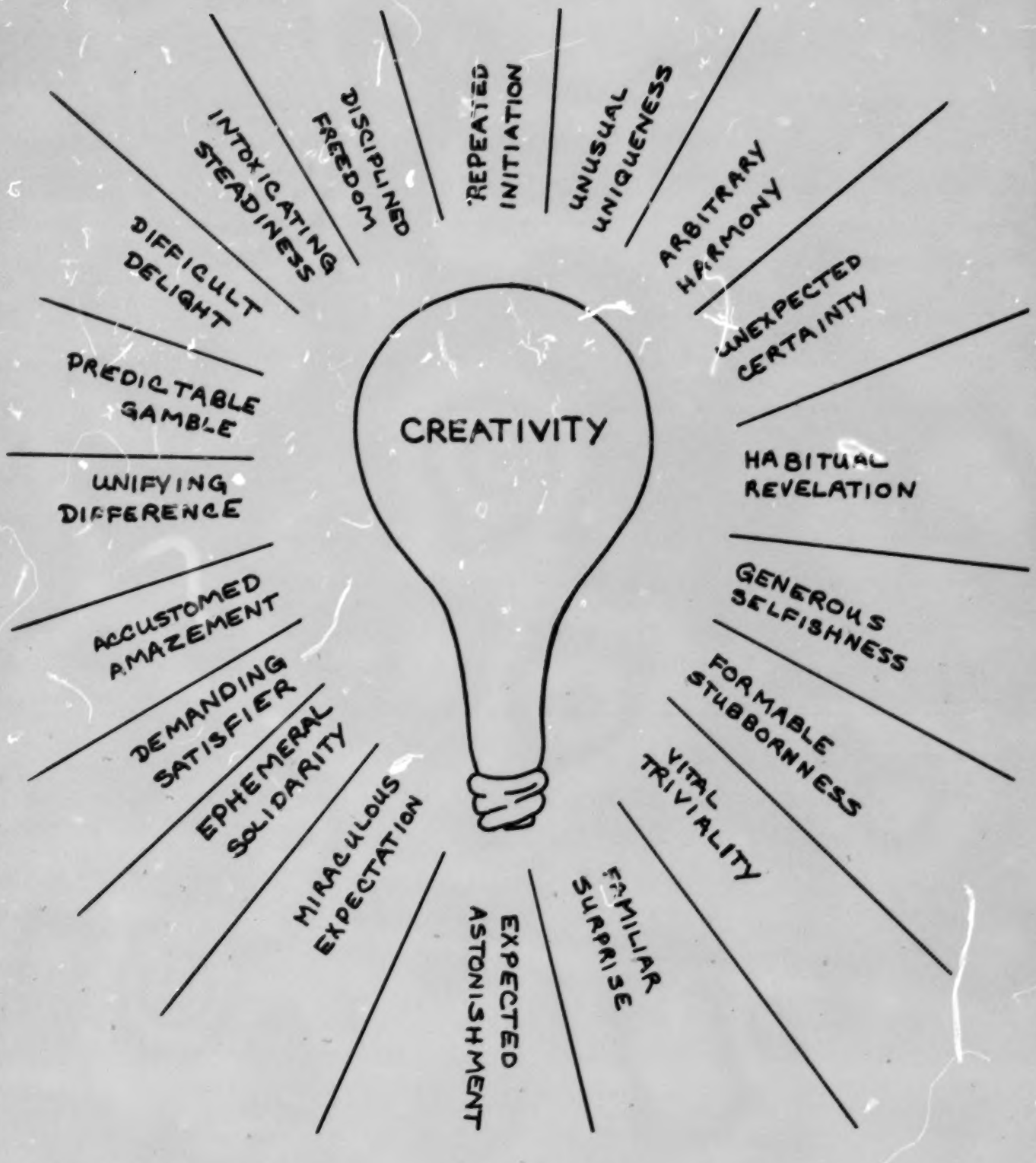
ask for examples from the social sciences, the arts, from the field of entertainment, or from some area of experience as far removed as possible from the original context. Other realms of experience might be weather, religion, family life, transportation, etc. To illustrate, the leader might ask for examples of "heat" in the field of entertainment. After several examples have been given, the leader asks for further explanation of one of the examples. By way of further explanation, the participants would give descriptive facts or associatory and speculative statements about the example.

Book Titles: The leader selects a word or phrase from the previous excursion and asks for a book title. In this context book title is a two-word phrase that captures the essence of the meaning of the word selected but which also has a built in paradox. It is important that the participants understand that the title of a real book is <u>not</u> what is wanted, only a phrase such as might be used for a book title. The figure on page 4-6-11 provides examples of book titles that capture the essence of the meaning of the word, "creativity" and which have a paradoxical element. The book titles in the figure are adapted from Prince (1970).

Personal Analogy: The personal analogy calls forth three degrees of involvement on the part of the participants: facts, emotions, and empathic identifications with the phenomenon. Using the example of a tuning fork, a first-person description of facts would be "I vibrate at a fixed frequency." A first-person description of emotion would be "If you whistle my note, I feel I am going to pieces." An empathic identification would be "I'm dead to everything but my frequency and then WOW!"

In the example, the leader began the excursion by asking for examples of vouchers from the physical world. Participants responded with electrical

The Creative Process of Prince 4-6-11



charges, gas under pressure, and a boulder on a precipice as examples of vouchers in the sense of stored energy.

The leader then moved to the next step in the excursion and asked for two-word phrases such as book titles which capture the essense of the example and include a paradox. Book titles for the "boulder on the precipice" were immovable energy, Sisyphus attained, stable mobility.

Changing to another subject area, the leader asked for examples of stable mobility from the arts. Responses included cubist paintings, mobiles, and water beds.

Taking an example which captured his imagination and seemed unrelated to the problem, the leader moved on to the next phase of the excursion and asked for a personal analogy--how does it feel to be a water bed. In abbreviated form, some of the feelings expressed were I feel restful and serene, I'm wet, I feel heavy and contained, yet I am restless.

The leader picked up on the idea of restlessness and asked for examples of restlessness from the life sciences. Responses included an amoeba, a buzzing bee, evolution because change is always occurring, osmosis because molecules are always moving, the constant circulation of blood, embryonic development, and the perpetual transmission of stimuli which takes place in the nervous system.

Force Fit: According to Prince, this is the most difficult portion of the procedure. The metaphorical material, in spite of its apparent irrelevance, must be forced to fit the problem. The leader says, "How can we use these ideas to help attain our goal?" or, the leader makes some loose associations, hoping the participants will respond. Another approach is to relate specific elements of the excursion to the problem. Finally, if all fails, the leader asks for the solution that if you proposed it to your boss he would immediately fire you!

Each force fit operation should yield a viewpoint.

Viewpoints: Viewpoints are suggestions that show promise for solving the problem. In the example after the leader decided that enough ideas had been expressed, he asked the participants to look over the ideas posted on the wall and to attempt to force these ideas to fit the problem. A variety of viewpoints or possible approaches to the solution of the problem were expressed.

To minimize the threat of change, it might be possible to use evolution as an example of gradual natural change. The idea of circulation led to the suggestion that teachers circulate through schools teaching at different levels and in different subject areas. Examples of restlessness might be used to help teachers understand the process of change. From the notion of gas under pressure came the suggestion that students sometimes "spill over" into new areas of interest. The example of osmosis suggested that by having some teachers model futurist behaviors these behaviors might be diffused to other teachers. The example of a mobile suggested that more opportunities for all kinds of mobility be provided for students. By providing teachers with an understanding of development and of the functioning of the nervous system as they relate to the learning process, they might be encouraged to perceive change as a natural and nonthreatening process. Thus by the synectics excursion away from the problem, many ideas were generated that proved to be applicable to the problem.

Summary and Comparison of the Processes

The steps in the two processes are summarized in a very simplified form in the two columns below:

Parnes' Processes	Prince's Process
Removing barriers to creativity	Statement of problem
Statement of problem	Immediate solutions
List ideas	Views of ideal solutions
Word associations	Selection of goal
List more ideas	Excursion (includes removing barriers to creativity) book titles, examples and explanations, personal analogies
Word associations	
List more ideas	
Evaluate ideas	Force fit
Combine best of several ideas	Viewpoints
Implement a solution (try to find all possible things that could go wrong)	

In Parnes' process there is a separate deliberate effort to remove barriers to creativity at the beginning of the process, in Prince's process attempts to remove barriers are built into the excursion. Both processes attempt to assist the participants in associating ideas and information that they would not ordinarily associate. The Parnes' process contains a more explicit effort to attempt to recognize all possible problems that might be encountered in implementing the solution. The Prince process stops with the generation of a number of viewpoints and leaves the implementation to those who are concerned about the problem. It does generally produce a wide assortment of possible solutions through <u>forcing</u> the ideas from the excursion to be used.

Some Practice Problems

These problems are adapted from a supplementary guide prepared by the Creative Education Foundation. You might want to use one of these problems and two groups of students to compare the two different processes of problem solving.

(1) Make a note of every opportunity you have had to use your creative imagination today.

(2) Cut out six cartoons, remove their captions and write new ones.

(3) List three uses for "flying saucers" that have just arrived from Mars.

Ideas Contributed by Participants

Several participants used various adaptations of creative problem solving procedures in teaching taxonomy. One was to select two organisms that are quite different and invent a classification scheme that would place them in the same category. Another was to have one group of students empirically classify about twenty specimens and another group learn their proper classification by rote memory. Many students felt that they had learned more from the first method; a few were quite content to memorize what they were told.

Using techniques for reducing barriers to creativity and word association methods, an anatomy and physiology class and some other classes were helped to generate concepts about structure-function relationships in imaginative ways. Student comments ranged from, "Even the craziest answers lead up to something . . .", to "I feel it's better when you give us facts, then we're sure what you want us to know."

Other ideas discussed were techniques for incorporating management skills in science courses and the creation of a total curriculum to foster the development of technological humanists, which includes interdisciplinary work and emphasis on problem solving.

Decision Making Processes

Decision making is a major component of almost all problems that need solving. One of the problems frequently encountered is the difficulty of deciding which of several possible actions will be most satisfactory. Rubinstein (1974) discusses decision making theory at some length. While it is beyond the scope of this study guide to do more than merely introduce some ideas, perhaps these ideas will help you to determine whether you want to delve further into the theories and their

applications. One way to visualize the decision making process is to prepare a matrix as illustrated at the right. Tabulated in the rows are alternative actions that might be taken and in the columns are several conditions that might affect the outcome of the decision. Each cell in the table represents a different outcome; in each cell can be entered the estimated degree of satisfaction expected from that outcome. The objective of any decision making process is to maximize expected satisfaction.

Alternative actions	Conditions A	B	C
1	Outcome A1 Satisfaction		
2			
3			
4			

In some problems, the outcomes are certain. If there is a small number of certain outcomes, it is fairly easy to assess the relative satisfaction of each. In other problems, the outcomes are not certain but there are known probabilities for each of the conditions. (In flipping a coin, the outcome is not certain but the probability of each outcome is known.) The payoff for each possible decision under each condition can be calculated as the probability of the outcome times the satisfaction level expected from that outcome. The individual or group making the decision, of course, decides its own satisfaction levels. Other more complex problems are those in which each action can have two or more outcomes but the probabilities are unknown, and those in which the conditions are replaced by courses of action open to an opponent who is trying to maximize his objective. (The matrix would have actions of opponent entered in the columns.) Such decisions under conflict are the kinds of decisions which game theory deals with. Game theory assumes that players are rational and attempts

to weigh the outcome of various strategies. Zero-sum games are those in which the winner wins by the same amount that the loser loses. In non-zero sum games, this is not the case.

Conflict Resolution

The techniques described below are adapted from Wehr (1972). There are a great number of problems of social significance which have scientific components; many of these problems involve some kind of conflict. For example, city planning, highway construction, resource conservation and utilization, legislation pertaining to drugs, abortion, use of pesticides, etc.; these and many more examples could be cited for which there is no one generally accepted position held by all members of our society. This adaptation of Wehr's techniques is designed to be carried out by two or more groups of six to eight students. The groups of students might be formed by the voluntary association of students with similar viewpoints. Then the groups would be actually in conflict over some aspects of their viewpoints. The advantage of this arrangement is that while the students are learning techniques for managing conflict they would also be resolving conflicts that actually exist among them.

To begin: To begin the conflict resolution technique, select a problem about which there is natural conflict. Ask the students to form groups based on their actual views about the issue. In using this technique for the first time, it is recommended that only two groups be used. While this may artifically limit the complexity of some problems where there are three or four conflicting viewpoints, it does make the situation manageable. After students have acquired some experience, more complex issues with multiple positions may be used.

Study of the situation: After the issues and the groups are selected, each group

makes a study of the situation. As a possible procedure, each member of a group might take the responsibility for collecting the information for one or two parts of the study, after which the team would meet to go over the information and resolve any possible conflicts among themselves in interpretation of the information. (This may call for an application of the techniques within sub-groups of a group before the process of resolving the first issue may take place.)

(1) History of the conflict

a. What are the objective facts?
b. How does your team perceive the conflict?
c. How do you think the other team(s) perceive the conflict?
d. How do you think the other team(s) perceive your position?
e. Restate the issue as clearly as you can.
f. How are identities of groups involved in the issue?
g. Have there been conflicts over this or similar issues in the past? If so, summarize them.

(2) Values and interests at stake in the conflict situation

One approach to this portion of the study is to tabulate your team's views and those of the other team (or teams, if you are dealing with a multiple issue problem) in separate columns of a table. This will serve to emphasize areas of agreement and areas of conflict. Any information on the other team(s) should be collected as objectively as possible and the team should guard against any tendencies toward "wishful thinking" (that there is less conflict than actually exists) or toward seeing other teams as the enemy or the "bad guys".

	Your team's values and interests	Those of the other team(s)
a. material needs b. self-development c. access to authority and power d. status and prestige values e. ideological and cultural beliefs f. identities (right of different parties to exist as equals)	(Use as much space and as many columns as necessary to record complete answers.)	

(3) Communication patterns

a. What coverage has been given the issue by the newspapers, TV, radio?
b. What other formal or informal communications has taken place--meetings, etc.?
c. What possibilities exist for misinterpretation?
d. What possibilities exist for rumor to interfere with precise and open communication?
e. What organizations exist or could be created for gathering and disseminating factual information?

(4) Level of threat perceived

As in item (2) this item should be tabulated by your team for its own views and by your team for how you think the other side sees the issue.

	Your team	The other team
a. Is physical safety threatened?		
b. Is stereotyped thinking contributing to the threat?		
c. Are there deterrents to threat operating?		
d. Are there any changes in the number of supporters for either side?		

(5) Transactional levels

a. Under what circumstances do members of opposing team(s) interact?
b. Are these interactions ad hoc, sporadic, recurrent, enduring?
c. Is power fairly equally distributed among teams or is one much more powerful than other(s)?

(6) Authority structure

a. Who has authority in situation?
b. What kind of authority--decisive, hesitant, capricious, reasoned?
c. Is there potential for creative intervention?

(7) Leadership within conflicting parties

	Your team	Your perception of other(s)
a. Who are leaders?		
b. To what extent do leaders represent constituency?		
c. To what extent are leaders' reputations at stake?		
d. What degree of control does leadership exercise over constituency?		
e. Are there members of leadership trained in conflict management?		
f. Is motivation to cool it down or stir it up?		

(8) Existing conflict patterns

a. Is legal system involved? If so, how are courts likely to deal with situation?
b. What implicit or informal rules apply?
c. What mediating mechanisms are available or could be made available?

(9) Costs incurred by parties to achieve goals

a. What are possible trade-off points?
b. What are some of the actual cost--human, property, financial?

(10) Relationship of conflict to larger society

a. Is this specific conflict related to larger conflicts?
b. Who are the outsiders and how might they become involved?
c. What is the influence of national mood on this issue?
d. Are there demographic or socio-economic factors (sex, race, ethnicity, etc.) involved in the issue?

When your team has completed the above data gathering effort, you should get together and discuss your findings. Your team should be able to arrive at a consensus about the data and its interpretation. (If you cannot, you may want to apply some of the conflict resolution strategies to the deliberations within the team.)

Drafting of the "Yesable" proposal: This portion of the technique is adapted from Fisher(1969). Start by deciding what action you would like to have the other team(s) take. In the first part of this technique, it was intended that the data gathering activities be as authentic as possible. In this part, because the teams are going to be negotiating directly with each other the teams must decide together whether they are drafting proposals to fit the real situation or whether they are to fit the actual membership of the teams. If the real situation is to be simulated, it is advisable for team members to be assigned the roles of actual current leaders of each side of the issue.

In drafting the proposal, attempt to cause the others to make as good a decision as can be expected in the situation. Ask yourselves, "How ought we

formulate our objectives, not what are our objectives." Take the opponents' situation, feelings, attitudes, desires, fears into consideration.

The proposal should be so clearly stated that a simple "yes" would be an effective answer. Consider carefully whether you wish to make any threats. Each time a threat is carried out and the opponent loses something, the loss suffered leaves him with less and less to lose. Your team will also incur some losses in carrying out threats. The decision to threaten can be all too easily made without considering the cost of following through to save your credibility. If you decide to make a threat, make it specific and short term--not an always and forever policy.

You may find the following chart useful in formulating your proposal in "yesable" terms for the opponent(s).

	Decision you want opponent to make	What you offer if decision is yes	What you will do if the decision is no
Who?	Who is to make the decision?	Who benefits if the decision is yes?	Who gets hurt if the decision is no?
What?	Exactly what decision is desired?	If yes, what benefits are there? What costs? (to the opponent)	If no, what risks? What potential benefits? (to the opponent)
When?	When does decision have to be made?	When will benefits occur?	When will consequences be felt?
Why?	Why is decision right, proper, lawful?	What makes it fair and legitimate?	What makes consequences fair and legitimate?

One useful strategy to consider in preparing your "yesable" proposal is to ask for a different decision. Any conflict grows from a previous situation where the opponent probably didn't do what your team wanted. Asking for a different decision puts the matter back on their agenda and a favorable decision does not now require a reversal of a previous decision. You should be aware that by asking for a different decision, you let the opponent know that you will change

your offer and might again.

Avoid these following errors: (1) not identifying specifically what decision you are requesting, (2) making an unrealistic request, and (3) making an unnecessarily ambiguous request. Know who is in a position to make the decision you are requesting and what decisions they are capable of making. Consider long term results of your request. Here are some qualities of conduct you might want to seek:

Do what we want you to do.	Stop doing what we don't want you to do.
Make us a promise.	Negotiate toward an agreement.
Make us an offer.	Explain or describe your position.
Respond to our offer.	Don't start doing something that you are not now doing.

Ask for a decision that, if it is not made, you will be able (1) to go ahead and achieve your aims anyway or (2) to carry out a specific threat in which you have a strong self-interest. Make a specific request but let opponent fill in details of how he will do it. One problem with too specific a request is that it puts an upper limit on what can be hoped for. Be specific but not rigid; use illustrative examples, not fixed minimum requirements. Draft your formulation of the desired decision, the yesable proposal, carefully. Fractionate the problem; use "salami" tactics and move ahead one slice at a time. Consider carefully before "padding" the request (asking for more than is expected). Padding scares off customers, makes it easy to have the request used as propaganda by the opponent, and retreating becomes awkward.

Make as attractive as possible what happens if the opponent makes the decision you want. Prepare a balance sheet of payoffs for "yes" and "no" decisions using your best judgment about how the opponent views the situation. Use the following format for the balance sheet.

Proposal: _____

	"Yes" decision	"No" decision
Positive consequences for opponent		
Negative consequences for opponent		

Some ways to make the proposal more attractive are to reduce political costs, reduce the effects of setting precedent, make the offer credible by putting money in escrow, thus demonstrating commitment. Put the offer in specific terms (date, action) and have specific plans for implementing your part of the offer. Have contingency plans. Keep your own reputation high and avoid bluffs. Make benefits immediately follow the desired decision. Provide a fading offer--the longer you wait to decide, the less you get. Offer to meet at a specific time to negotiate, don't say we are always ready to negotiate.

Make the most of legitimacy. Formulate the decision so it appeals to the opponent as the legitimate and right thing to do. Give them a justification that is acceptable to them and their constituency that the desired decision is right. If a decision furthers the opponent's own cause it will be easier for him to accept it. To give legitimacy to an offer, make the decision consistent with opponent's past actions, make it on what proposer is legally entitled to, make it reflect the view of an impartial third party. The consequences (benefits and penalties) should also be legitimate. Use terminology of the opponent, coordinate consequences with the decision itself, and avoid blackmail.

When you have your proposal prepared, present it to the opponent. Do this as a simulated classroom situation but carry it out in ways as nearly like what you would expect to happen in the real world as possible. Continue negotiations until

a solution has been reached. (See Unit 7 Simulated Situations.)
Evaluation of the solution and the procedures: Use the following criteria for evaluating the solution: (1) non-violent, (2) basic social needs of all parties met, and (3) reasonably mutual satisfaction of all parties with the settlement. Evaluate the procedures used in reaching a solution. Did you follow the suggestions in this guide? Did you find some useful techniques that are not mentioned here? If so, please share them. How could you use what you have learned in this simulation to make your efforts more productive in a real situation?

A Small Group Problem Solving Model

The following problem solving model is a composite of the ideas of Gordon (1970) and Prince (1970) and is designed for use in smaller groups than might use the conflict resolution model. It could be used within teams in the conflict resolution model. This model might be suitable for helping students to define their own learning goals, for helping faculty members to agree upon instructional procedures, or for other problems in which it is important that a small group arrive at a decision that is agreeable to all parties. Additional information about Gordon's methods is provided in Unit 8 Values Clarification; briefly, it is based on mutual trust and active listening. All participants need to become able to send clear messages about how they feel about a problem.

(1) Identify and define the problem: (Choose a suitable time and place. Stress the importance of the need to solve the problem.) Participants then describe the problem as they see it, which of their needs are not being met, how they feel about problem. Avoid messages that "put-down" or blame others. Stress that the method requires that <u>all</u> participants agree to the solution; problem isn't

solved until all are honestly satisfied with solution.

(2) Generate possible solutions: Solicit the participant's immediate solutions. All ideas are to be accepted and noted on a blackboard or easel. Do NOT evaluate or judge ideas at this point. That comes later. Encourage all participants to offer at least one possible solution.

(3) Excursion: Use metaphor and analogy to get away from the problem. Ask for:

Examples and explanations (e.g. examples of constancy from the realm of weather, barrier from the graphic arts, etc. Select the words from previous notes and the area from outside the experience of most members of group or from very common experience)

Book titles (e.g. a two-word phrase which is "catchy" like a book title but not the title of a real book. One word must be a synonym for the word given by the leader; the other word must create a paradox, for example, door = penetrable barrier, vibration = stable mobility, creativity = predictable gamble or difficult delight)

Personal analogy (e.g. pick a word and ask participants how it feels to be a . . . Use notes from steps in excursion to suggest additional solutions to the problem.

(4) Evaluate the alternative solutions: Which solution looks best? Decision theory could be applied here. Get participants' views about alternatives. Why is one better? Which ones are not acceptable? The reason for non-acceptability is not important so avoid "put-downs" for the person who made the suggestion.

(5) Decide on the best solution: Test remaining solutions against views and feelings of participants. Indicate that decision does not have to be final; if it doesn't work, the group can always "re-solve" the problem. Be sure all participants understand exactly what they are agreeing to and exactly what their part of the bargain is.

(6) Implement the decision: Who's to do what? How often? How well? Assistance? Cooperation? Coordinating efforts with others? Are there deadlines?

(7) Follow-up evaluation: Decide when results will be evaluated. Sometimes an informal checking among participants will ascertain whether everybody is still

satisfied with the solution to the problem. This serves to give participants an opportunity to demonstrate concern for others in the group. Those who have gotten "more than they bargained for" have an opportunity to say so. Sometimes modifications of the original decision are called for; sometimes the problem must be solved over again.

The Role of the Teacher

The teacher's role includes helping the students to learn the procedures for problem solving, assisting in the collection of information, and leading a discussion of the effectiveness of the problem solving method. Teachers could also participate in any one of the procedures, preferably as a co-worker on the problem and not as an authority who already has a solution. It is often a good practice to use problems suggested by students--problems they have an interest in developing insights about solutions.

In fostering creativity, the teacher can do much to create the atmosphere in which people accept each others' ideas and defer judgment, where people feel free to contribute ideas no matter how silly or impractical they seem at first. With practice, people come to realize that the "silly" ideas sometimes suggest alternatives which are quite practical and which might not have been thought of except through the "silly" idea.

Problems of Implementation

Shifting from a content oriented course to the use of problem solving procedures requires a change in attitude--an acceptance of the idea that problem solving capabilities are more important than mastery of content alone. Openness to this idea and willingness to try some of the problem solving methods may result in the discovery that students master a significant amount of factual

material and do so in a meaningful context. The time to do extensive research on problems and the availability of necessary reference materials may create difficulties. Some laboratory time might be relinquished to this task and all available community resources should be utilized. The major problem of implementation is likely to be in creating the atmosphere in which students feel it is safe to express ideas. Groups of three or four students can work together on creative thinking problems, even in large lecture classes.

Evaluating the Effectiveness of Creative Problem Solving Strategies

In determining the value of the various strategies presented in this unit, the following questions could be used:

(1) Did participants become more conscious of their own blind conformity?

(2) Did efforts to enrich experience result in greater creativity?

(3) How successful were the activities designed to eliminate or decrease blocks to creativity?

(4) Did participants become more able to generate ideas?

(5) To what degree was the reluctance to express "silly" or trivial ideas overcome?

(6) Did participants become more able to defer judgment on ideas?

(7) Was the problem solved?

Ideas for Research

Any of the problems presented in this unit could be given to different groups of students under different conditions (carefully controlled). The number of ideas generated or the quality of the solutions produced could be compared. The section of Unit 1 on research designs should be helpful in this context.

If an exercise intended to increase creativity of a group is planned, a problem might be given before the exercise and another similar problem after the exercise to make it possible to assess the effects of the exercise. An example is "How many uses can you think of for a pencil?" Limit time to three minutes. An alternative question is to substitute "penny" for "pencil". Before the exercise half the group could list uses for a pencil while the other half lists uses for a penny. After the exercise the questions could be reversed to preclude differences being due to the item.

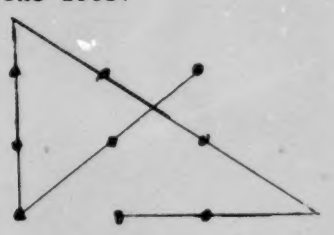
Refer to the chart you were directed to prepare on page 4-6-2. Try to formulate from that chart the pattern of thoughts and feeling you experience while attempting to solve a problem.

Ideas for further research are solicited from participants. Creative ways to study creativity are needed and the problem should present a challenge.

Answers to Problems

Before reading solutions go back to page 4-6-2 and try solving the problems again. (You really should be more creative now!)

The dots:



The matches: Build a triangle on the table, then stand the remaining three matches up to form a tripod. You have just built a tetrahedron. Have you ever used the model to explain carbon atom structure?

In these two problems you probably thought only of space within dots or in one plane.

The red poker chip is most likely (probability = 2/10) to be drawn on the first draw. Probabilities are shown in the table below:

Draw #	1	2	3	4	5	6	7	8	9
Expected number of red draws of 100 draws	20	17.6*	15.6	13.3	11.2	8.9	6.7	4.4	2.3
Proportion expressed as a fraction	2/10	2/9	2/8	2/7	2/6	2/5	2/4	2/3	2/2
Total draws remaining out of 100	80	62.4	46.8	33.5	22.3	13.4	6.7	2.3	0.0

*Expected number of red draws out of 100 = probability x total draws remaining out of 100. For example, 2/9 x 80 = 17.6

Self-Assessment

A-1. Describe how creative problem solving is related to learning theory. (1)

A-2. Discuss how you helped students remove barriers to creativity. (2)

A-3. Discuss how you elicited creative ideas from your students. (3)

A-4. Describe how you helped students to develop decision making abilities. (4)

A-5. Discuss how you applied conflict resolution techniques in your teaching. (5)

A-6. Describe the role of teacher in problem solving. (6)

A-7. Discuss problems you encountered in implementing problem solving techniques. (7)

A-8. Prepare a report which shows the degree of effectiveness you experienced using the techniques in this unit. (8)

A-9. List at least three researchable questions about teaching strategies to foster problem solving. (9)

A-10. Carry out an experiment to answer one of the questions posed in A-9. (10)

B-1. Propose additional strategies for removing barriers to creativity and for eliciting creative ideas. (2,3)

B-2. Develop new methods of fostering decision making and/or conflict resolution. (4,5)

B-3. Discuss your experience in the role of teacher in problem solving situations and suggest additional comments about that role which might be included in this guide. (6)

B-4. Propose some strategies for avoiding some of the problems you experienced in implementing problem solving techniques. (7)

B-5. Suggest improvements in the questions for evaluation and in the ideas for research. (8,9)

B-6. Carry out another research project or write a careful critique of the first project. (10)

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UNIT 7

SIMULATED SITUATIONS

> Then said a teacher, Speak to us of Teaching.
> And he said:
> . . .
> If he is indeed wise he does not bid you enter the house of his wisdom, but rather leads you to the threshold of your own mind.
> . . .
> For the vision of one man lends not its wings to another.
>
> Gibran, The Prophet, p. 56.

Purpose and Objectives

Simulated situations, as defined here, include games and role playing situations designed to create a learning situation as near like a real situation as is possible. This unit is intended to provide some experience with using role playing and games as alternative modes of instruction. Upon completion of this unit, you should be able to: (1) define simulation, role, playing, role-playing, and game, (2) relate the techniques described here to learning theories, (3) use at least one role-playing situation and one game with your students, (4) describe some qualities of the role of the teacher that increases the effectiveness of simulations, (5) describe some problems of implementation and suggest some ways the problems might have been dealt with, (6) evaluate the effectiveness of the simulations you have used, (7) design a research project to study the learning effects of simulations, and (8) carry out the experiment you designed.

4-7-2 Simulated Situations

Definitions

To simulate is to create the effect of; a simulated situation creates the effect of a real situation. It offers learners an opportunity to practice dealing with a situation, which either is not available or requires some preparation before the learner can benefit from experiencing the real situation.

A role is an assigned or assumed character. Learners assume roles in simulated situations to experience how the role feels and to test their abilities to deal effectively with the problems encountered by a person in that role.

Playing, often used to mean engaging in recreation, also means taking part in or acting in the character of. It is the serious connotation that is intended.

Role-playing, in this context, is the acting of an assumed character in a simulated situation for the purpose of learning more about the character and the situation. In this unit, we will consider two kinds of situations: (1) those which help students to understand the complexity of contemporary problems and (2) those designed for teacher training.

A game is often thought of as a competitive activity requiring skill, luck, or endurance. A game might also refer to or involve a strategy.

In this unit we will be concerned briefly with two kinds of games: (1) games that simulate environmental and sociological situations, and (2) some unconsciously played "ulterior motive" games, which are mentioned to point out how teachers and students can keep from becoming entrapped in such games.

Relationship to Learning Theory

Simulations and games generally require problem-solving and the insightful

higher cognitive levels of learning. They also involve affective learning as well. Only when players are learning the rules of the game is memory level learning involved.

The use of simulations and games is an excellent example of the application of Gestalt-field theories of learning. Learners are interactive as participants in the situations. The participant's perceptions of the situation and the meanings he attaches to those perceptions determine how he interacts with others in the situation and how he contributes to solving the problem. Behavior is goal directed toward formulating and solving the problem. Motivation for learning comes from the challenge of the situation.

How to Use Simulated Situations

Scientific information and principles can be applied to the solution of many contemporary problems. Furthermore, part of the task of teaching science should be to help students discover how their learning can be applied to dealing with problems that concern them. The following steps (adapted from Lehman, 1971) describe the process:

(1) Select or design (or have students design) a situation. The situation should have real significance to the students and should require the application of scientific information and principles.

(2) Prepare short descriptions of each of the roles to be used in the situation. Attempt to create roles that are authentic. Start with situations with only a few (3-4) roles.

(3) Describe the situation to the class and assign roles. (No one should be forced to participate.) It is often helpful if the instructor knows the students well enough to assign roles that fit the personality of the student.

Alternatively roles might be assigned that purposely do not fit the personality of the student, to give that student an opportunity to experience how it feels to be in a position different from what he usually experiences. For situations intended to develop the students' abilities to deal constructively with unexpected circumstances, it may be desirable to assign each role privately, so no player knows what other roles have been assigned.

(4) Decide on a time and place for the simulation. This will usually be a regular class meeting. If the class is a large lecture section, it may be appropriate to select a small group of students to demonstrate the simulation to the rest of the class. If it is possible to use simulations in small groups (seminars, discussion sessions), the involvement of the class can be much greater. Generally it is a good idea to allow a week or so for the students to prepare for their roles by looking up the information needed to support their positions. An alternative method is to assign the roles and immediately begin a trial simulation. Students will quickly discover the kinds of information they will need to play their roles effectively. The simulation can be repeated after the role-players have had time to prepare for their roles. If roles of public officials or local citizens are involved in the situation, it may be helpful to have the students interview the people whose roles they will play. Some simulations of interviews might be useful to help students learn interviewing techniques.

(5) Carry out the simulation. Some ground rules should be agreed upon at the beginning: (a) Any participant may request that the situation be "cut" at any time, if that person feels particularly uncomfortable in the situation. (b) The director may "cut" the situation at any time he feels that it is not a productive learning situation. (c) At no time should the simulation come to

resemble a therapy session. The purpose is to gain experience applying scientific information and principles to dealing with contemporary problems. If a HOT issue has resulted in non-productive, emotional reactions, the situation should be "cut". A discussion of what went wrong might be informative. (6) Critique the simulation. Some of the following questions might be asked of the participants: (a) How did you feel in the role you played? (b) Did participation in the situation lead to new insights about the problem? If so, what are those insights? The observers (members of the class who did not have roles) might be asked whether they obtained new insights from observing.

Examples of Simulated Situations

MEETING OF THE CITIZENS' COMMITTEE ON CITY PLANNING

Suggestions to the instructor:

A fact sheet describing the population, tax base, types of industry, type of city government, population growth rate, land values, current pollution problems, etc. might be helpful. Data entered on the sheet could be based on a local situation and the situation adapted to suit the situation. In using this simulation, it has been observed that if students independently "invent" data for the situation, there are discrepancies which interfere with an effective simulation. Even if some "invented" information is used, a fact sheet used by all participants will minimize confusion. The use of different sets of data in separate simulations can dramatize the different outcomes under different conditions. For example, if the hospital and school were not overcrowded, but industrial smog were severe, the kinds of things students learn and the way they resolve the issue might be different than if the population density and high growth rate were perceived as more serious than the pollution problems.

4-7-6 Simulated Situations

The Situation:

The issue before the committee is an application from the Eureka Real Estate Corporation for a zoning change on a five acre parcel of land at the northwest end of People's Park. The land is now owned by Mr. Fitzgerald and is undeveloped. Because of its location at the end of the park, it has been assumed by the citizens of the community to be part of the park. The city would like to purchase the land and incorporate it into the park; some of the staff of the Department of Parks are working on this problem. However, Eureka has made Mr. Fitzgerald a handsome offer of $35,000 for the land. Since he wishes to sell quickly, retire and move away, the Department of Parks is working against time.

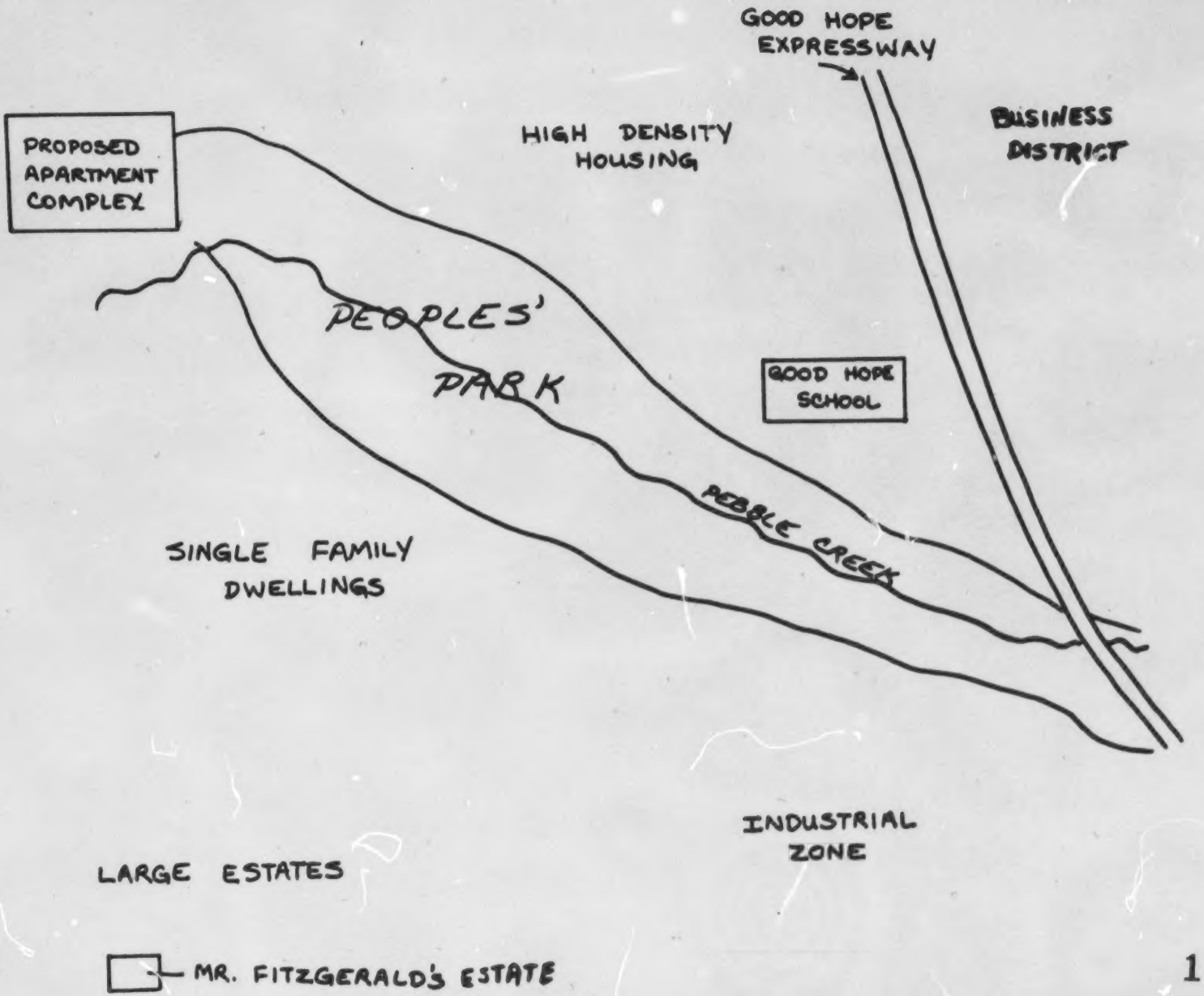
Eureka plans to build a high rise, 500 unit apartment complex on the land and they are pressuring for a zoning change to allow the construction to proceed. The city is a suburban area near a major city. There is a critical housing shortage mainly for families whose income is derived from the major city. Interest among the commuter citizens in suburban community issues is not high.

Roles:

While masculine pronouns have been used in defining roles, any role may be filled by a student of either sex.

Director of City Planning. Chairs the meeting, hard-headed business man, recognizes the need to deal with citizens' feelings but is much more interested in the economic growth of the city, which he equates with progress. Above all else, he keeps the meeting moving and focused on the issue of whether the property should be re-zoned.

Staff Assistant, Mayor's Office. Attending this meeting to find out for the mayor what sentiments are expressed. He is a "yes-man" to the director of city planning--if the director says it's good for the city, he thinks it's good for the city. An industrial engineer by training, brought onto


GOOD HOPE EXPRESSWAY
PROPOSED APARTMENT COMPLEX
HIGH DENSITY HOUSING
BUSINESS DISTRICT
PEOPLES' PARK
GOOD HOPE SCHOOL
PEBBLE CREEK
SINGLE FAMILY DWELLINGS
INDUSTRIAL ZONE
LARGE ESTATES
MR. FITZGERALD'S ESTATE

the Mayor's staff to help the city's industries cope with (evade?) environmental impact statements.

Eureka's public relations representative. Has all the answers to how the apartment complex can serve the city--more people, more business, etc. Apartments will be the last word in modern convenience, underground parking, low-discharge incinerator, space around buildings. Has considered putting a shopping arcade in the complex, but would readily drop this plan if local businessmen would, in exchange, support the rezoning.

Parent of children attending Good Hope School. The school is already overcrowded and the annex under construction will barely take care of current enrollment. The children from 500 new apartments would be the "last straw" for Good Hope School.

Citizen who fought the construction of Good Hope expressway. He is appalled at the idea of allowing this land to be zoned other than "undeveloped". He has made numerous attempts to encourage an agreement between the city and Mr. Fitzgerald to obtain the land as an extension of the park.

Stock broker. He owns a large estate on the south edge of the city and commutes to the "big city" each day. The only way to keep the economy on the upswing is to provide more industry, more housing, more goods for the increasing population. He has quietly let it be known to a few people that he would be interested in investing in the apartment complex.

Nurse. He is concerned about the serious overcrowding of the city hospital and the inadequate health care delivery for the present population; active in several organizations dedicated to limiting population, he advocates a moratorium on all building and the establishment of an upper limit on the city's population.

Staff member, Parks Department. He sees the land in question as an ideal location for a nature center, since such a center should be located as far from the expressway as possible. He has made numerous attempts to persuade city to purchase the land from Mr. Fitzgerald.

Operator of local independent business. It is hard enough, today, for an independent business to survive. Extra people would help, regardless of whether they work in the community or commute to the "big city". "I pay my taxes and if owners of big apartment complexes paid their share, we would have a larger tax base for schools and hospitals."

Director of Public Utilities. The present sewer system will not handle the new apartments. Even without construction, during heavy rains the run-off overflows the sewers and pollutes Pebble Creek. The city experienced several power brown-outs last summer and the generating plant is operating at full capacity. Even though the city is part of a power-sharing grid, overloads could disable much of the city.

Mr. Fitzgerald. Owner of the land is willing to sell to the city but not willing to take a serious financial loss. He is relatively neutral with respect to environmental issues but has perceived himself as something of a philanthropist for having allowed his land to be used as an extension of the park. He is only mildly enthusiastic about the apartment complex; mostly he wants to sell to somebody so he can get his money out of the land.

Other members of the class could attend the meeting as citizens of the community. Some might want to create their own roles, either as community spirited individuals or as "just a commuter who wants a nicer apartment".

Critique of Simulation:

As the director/teacher you might ask the following questions: How does it feel to play the role of _____? (to each of the role-players) What kind of research did you do to collect information needed to play your role? Were you caught unprepared by some information ferreted out by another participant in the situation? Did you (participants and observers) gain any new insights into the complexity of the problem?

LEGISLATIVE SUB-COMMITTEE HEARING

Suggestions to the Instructor:

You should prepare for this simulation by becoming informed about parliamentary procedure and the conventions of legislative hearings. A review of Roberts' Rules of Order (1971) and Morrow (1969) on Congressional Committees might be helpful. For example, it is the prerogative of the chairman of the sub-committee to conclude the hearing when he has heard what he wants to hear. The first time I tried this simulation, the chairwoman heard all of the testimony from one side (the auto manufacturers), dismissed the hearing, and disappeared from the class. If there is a moral to this story, it is that if you are going

to give students the option of creating roles, you have to be prepared to deal with the situations they create.

The Situation:

Legislation is pending concerning the control of pollution emitted by motorized vehicles. The chairman of the sub-committee will read a prepared statement that describes the problem under investigation. He will then call witnesses, first (usually) from the side he favors. The witness reads his prepared statement. He may be interrupted by a committee member with a question pertinent to a statement he has just made. After the witness finishes his testimony, committee members take turns asking questions, first the highest ranking member of the political party of the chairman, then the highest ranking member of the other party. When the committee finishes interrogating the first witness, the chairman calls the second witness. The chairman decides whether to hear all of the witnesses on one side first or whether to alternate. He also decides when to terminate the process of hearing witnesses and may conclude the hearing before all witnesses have testified.

Roles:

Engineer for car manufacturer. Has all the reasons why the company cannot meet proposed standards.

Legal counsel for car manufacturer. May speak for engineer witness. Presents legal precedents which favor car manufacturer.

Executive of public transit company. Busses are most flexible means of public transportation, even though they pollute the atmosphere.

Legal counsel for transit company. Presents legal precedents in favor of bus transportation.

President of citizens' organization. Presents statistics on how many people would use rapid transit, if available; how many have respiratory ailments

that are aggravated by vehicle emissions.

Several individual citizens, including a Lawyer. Prepared to testify concerning violations of their civil rights.

Committee Chairman. His sentiments are pro-motorized vehicle.

High ranking member of chairman's party. His sentiments parallel those of the chairman.

High ranking member of opposition party. He is a scientist by training, champion of the cause for clean air and the "right to breathe".

Member of the Chairman's party. His particular concern is fiscal matters, favors whichever means of transportation that costs the least. (Witnesses should be forewarned that questions about cost will be asked.)

Member of opposition party. He is noted for his ability to look for long term solutions to problems.

After hearing testimony, a group of students could be assigned the task of drafting a bill to be presented to the legislative body. They might have attended the hearing as legislative aides to the committee members. The bill should take into consideration all of the problems elucidated by the committee members' questioning of the witnesses.

Critique of Simulation:

Refer to questions provided for other simulations.

GRASS ROOTS MEETINGS ON POPULATION CONTROL

Suggestions to the instructor:

You and your class may find it instructive to do this simulation two times, tape recording each simulation. (Role players in one simulation should not be present at the other simulation but may hear it on tape after they have completed their simulation.) Roles in one simulation should be assigned to individuals whose actual views are close to those expressed in the role; roles in the other

simulation should be assigned to individuals who would be decidedly "out of character" in the roles. Comparing the actual conversations during the simulations and the students' comments on them will provide some clues about empathizing with perspectives diametrically opposed to one's own. Learning to empathize with the perspectives of others is a valuable lesson in preparing a student to meet the challenges of contemporary society.

It should be noted that there is ample opportunity for students to learn a lot of science in preparing for this simulation: sexual differences, child development, food production, population dynamics, natural controls to population growth, eugenics, genetic engineering, racial differences, etc.

The Situation:

The possibility of modifying the income tax structure to allow deductions for only two children is being considered. The notion of a tax assessed on children beyond the limit of two is also being considered. The purpose of the simulated situation is to develop recommendations on changes in the tax law.

Roles:

Chairman. He is a representative of the legislature, assigned the role of determining citizen attitudes.

A self-styled Paul Ehrlich. He is married with one child; will have no more children. Because you believe in the dignity of man and that man should not be restricted by the constraints of over-crowding, you are very outspoken on the need for population control--compulsory control--now, before it is too late! You volunteer much of your time to the local chapter of Zero Population Control and have undergone sterilization for the benefit of future generations. You really get aggravated with people who are busy breeding the human race out of existence.

A "Women's Libber". He is a good student and has an active mind. Some day he would like to have one or at most two children, but right now he wants to finish college. He is acquainted with many women who contribute more to society than housework. He would like to see women have greater

opportunities for fulfillment in the outside world--and excellent child care facilities to free them to make use of the opportunities. Perhaps, then, fewer women would look to large families for their satisfactions in life.

A devoutly religious citizen. He is considering joining a religious order because of an interest in serving humanity. While you may remain childless, you believe that every married couple should thankfully accept as God's gift as many children as are given them. Technology will find ways of feeding people. Government does not have the prerogative to interfere with human life.

A physician. He has come to support liberalization of abortion laws after seeing the effects of multiple pregnancies on his patients and their families and after caring for patients who have suffered in the hands of "quack" abortionists. Motivated less by overpopulation than by experience with the plaintive cry of the mother of five who wants to abort her sixth child so she can retain her sanity to raise those she has.

A diabetic. Afflicted since early childhood. Mother was also a diabetic. You are well aware of the restrictions on the life of a diabetic but you have probably had it better than most because your mother has been very understanding. Since there has been much talk recently about genetic engineering and about prohibiting couples with genetic defects from having children, you are concerned that these views not become overriding considerations. You are a responsible citizen, self-supporting, and you resent the suggestion that individuals such as yourself be deprived of life.

Member of a minority group. You feel that this whole business of population control is an establishment plot to keep your race from having children. If it ever comes to compulsory population control, you know who will be controlled. You plan to have as many children as possible and instill in each of them the desire to fight for the rights of their race.

Critique of Simulation:

How does it feel to play the role of _____? What kind of research did you do to prepare for your role? Did the group as a result of the simulation, develop a set of recommendations with respect to revisions in the tax law?

VOYAGE ON A SPACE SHIP

Suggestions to the instructor:

The following situation can be developed by students in a more open-ended fashion than the above examples.

The Situation:

A space ship populated by 90 adults has left Planet Earth for a five year voyage to a planet in another solar system, which is known to have an environment similar to that on Earth. Only adults between the ages of 18 and 30 were allowed to go on the voyage which has been enroute for six months. Several committees have been created to plan for the establishment and development of a new social order on the new planet. Also within the responsibilities of the committees are the tasks of making all necessary changes in the existing social order enroute that will be needed to prepare for the landing and subsequent colonization.

Committees should be defined by the class participating in this simulation. Some suggested committees are: educational system, food, housing, transportation, medical care, environmental standards, recreation, economics, etc.

Every member of the class should have a role in one committee. The chairman of each committee is a member of the executive committee, whose responsibility it is to coordinate the activities of the committees and to assure that mutually inconsistent goals and methods are resolved. (An alternative structure could be created by the class if it is decided that the above suggested structure is too "earth bound".)

Assume that all printed materials available on Earth are available on microfiche and that there is a large computer on board. The current schedule of

space ship inhabitants calls for sleeping in three eight-hour shifts--there are 30 beds. The work of guiding the voyage, doing housekeeping and other essential tasks takes four hours per day per person, leaving 12 hours for planning and leisure.

Critique of Simulation:

The outcome of the committee meetings should be a compatible set of recommendations for how life will be lived on the new planet. Subsequent discussions should deal with how this plan compares with life on Earth today, whether individual students would prefer one or the other and why, and what scientific information was needed in carrying out the simulation.

MEETING OF THE TRANSPORTATION COMMITTEE OF THE COUNCIL OF LOCAL GOVERNMENTS

Suggestions to the instructor:

A fact sheet should be prepared to assure that all participants use the same data. The data used may be fictitious but should be reasonable for the time and place. You should modify this (or any other simulations) to fit local problems. The fact sheet might be in the following format:

Items	Metropolis	Northville	Southtown	Easton
Population				
Tax base				
Tax rate				
Median income				
Number of working adults in pop.				
Transportation used to get to work				
etc.				

4-7-16 Simulated Situations

Consultants should prepare reports to be presented at the meeting. (See roles below.)

The Situation:

A meeting of representatives of each of the local jurisdictions to explore ways to provide satisfactory transportation system for the four incorporated cities shown on the map. They will consider consultants' reports. As a result of the meeting, the committee is to prepare a proposal to be presented to the citizens of the cities.

Roles:

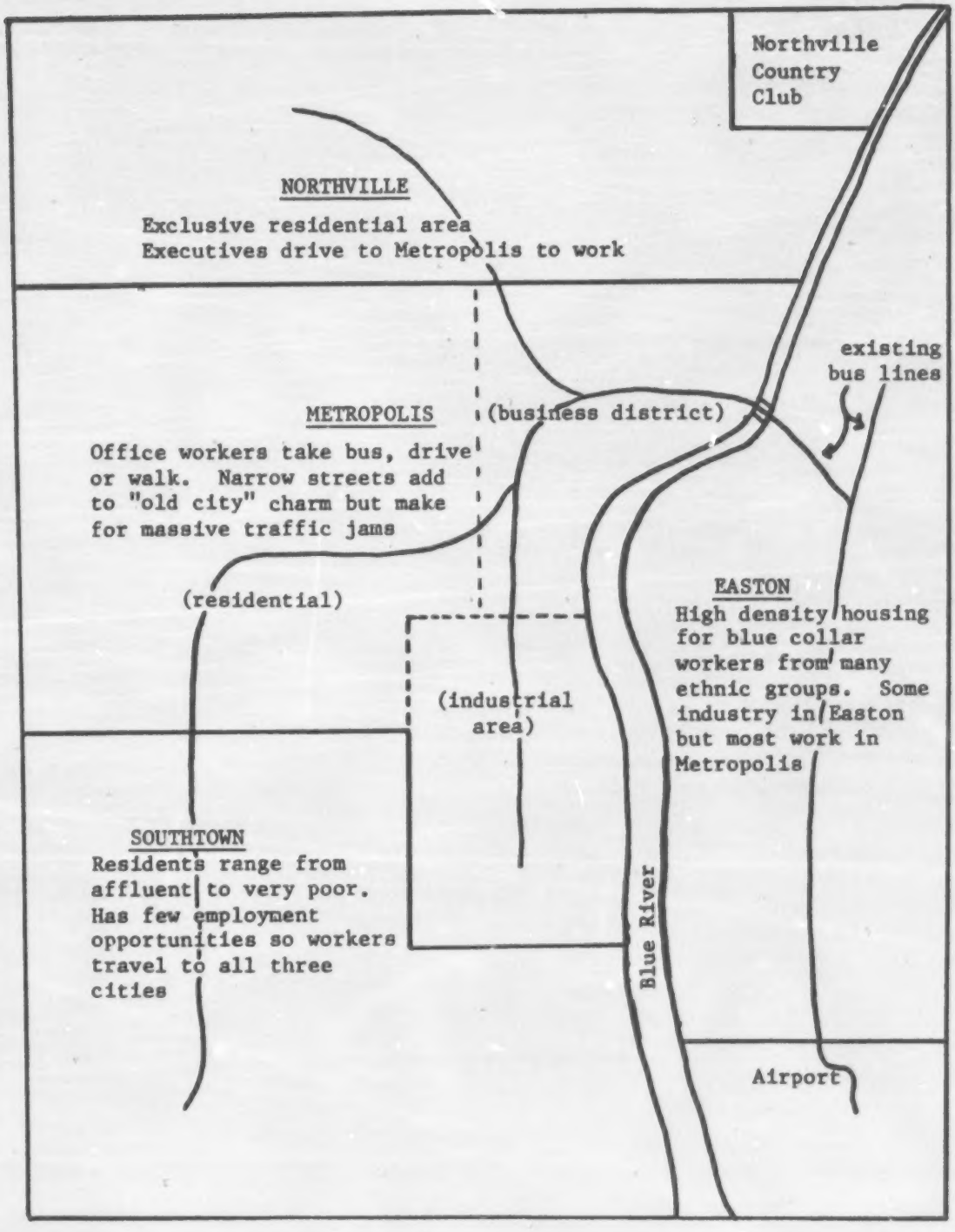
Representative of Northville (chairman of the coalition). He is trained in business, looks at dollar costs over environmental costs; short-range problems rather than long-range problems. His constituents are not in need of public transportation since most have two cars. Northville desires to maintain the status quo.

Representative of Metropolis. He has had extensive training and experience in city planning and is much concerned with making the old city a pleasant and convenient place for all citizens regardless of socio-economic status. He is more aware of sociological factors than environmental factors, but is willing to listen and learn.

Representative of Easton. A member of an ethnic minority, he holds an industrial management position, having worked up through the ranks. He is well tuned in to Easton's needs and well informed about environmental problems. He is determined to see that constituents have access to convenient transportation from homes to the industrial area of Metropolis.

Representative of Southtown. A retired plant foreman, he now devotes a lot of time to community activities. He recognizes diversity of opinions among constituents who range from affluent executives to welfare recipients and would like to see the plan provide convenient economical transportation for people employed in Easton, office and industry employees in Metropolis, and domestics employed in Northville. Also, he hopes to retain favor of the affluent who prefer to drive their cars.

Consultant A. He has completed a traffic survey and kinds of transportation desired by citizens of the four communities.


Northville
Country
Club
NORTHVILLE
Exclusive residential area
Executives drive to Metropolis to work
existing
bus lines
METROPOLIS
(business district)
Office workers take bus, drive
or walk. Narrow streets add
to "old city" charm but make
for massive traffic jams
(residential)
EASTON
High density housing
for blue collar
workers from many
ethnic groups. Some
industry in Easton
but most work in
Metropolis
(industrial
area)
SOUTHTOWN
Residents range from
affluent to very poor.
Has few employment
opportunities so workers
travel to all three
cities
Blue River
Airport

Consultant B. He is competent to advise the coalition on current and projected pollution hazards, on energy utilization by various forms of transportation, and on the effects of various land use proposals. He has a statistical report on these factors.

Consultant C. He has prepared a proposal for widening streets and building bridges to improve flow of bus and automobile traffic.

Consultant D. He has prepared a proposal for a rapid transit system.

Critique of Simulation:

The primary question is: Did the group develop a proposal that each representative felt he could present to the citizens of his city? Other questions might be: Were the representatives of each city concerned about satisfying the citizens of the other cities as well as their constituents? Did the consultants prepare adequately for the simulation? Did they present their information in ways that contributed to the development of the proposal? Did the committee members give careful consideration to the consultants' reports?

Examples Contributed by Participants in the Chautauqua-Type Courses

An Advocate Debate on the pros and cons of Vitamin C in treating the common cold was developed by John Clausz, St. Andrews Presbyterian College, Laurinburg, N. C.

A situation in which students, faculty, and health service personnel discuss and develop a recommendation to the Board of Regents concerning distribution of birth control pills to coeds was prepared by Charles Woodward, Shepherd College, Shepherdstown, W. Va.

An ecology project was created by Ann Marie Olson, Boston State College, Boston, Mass., in which each student prepares a position paper on an

ecological topic and then prepares a statement from the viewpoint of a particular type of person, such as an airline or automobile corporation president, a government official, a physician, a conservationist, etc. Students were asked:

> to come to class ready to be questioned and challenged on the stand which the person you represent would take. As you prepare your arguments, think about how they might be countered or challenged by other types of people that will be at the meeting. Be certain that you have documentation or at least reference to documentation, for the factual material that you present.

Students study historical and contemporary scientific controversies by taking the roles of investigators in a simulated situation, according to the procedure developed by Sr. Sheila Marie Scheirer, Chestnut Hill College, Philadelphia, Pa.

The Use of Simulated Situations in Teacher Training

Lehman (1971) has developed the use of role playing in teacher training to help prospective teachers acquire the skills of inquiry teaching (guiding students to ask questions and discover through the process of scientific experimentation) and to increase the teachers' interpersonal relations skills (in Lehman's words):

> establishing a climate of mutual respect in the science laboratory and classroom; accepting and expressing appropriately their own feelings as teachers; and accepting and responding adequately to the needs and feelings of individual students.

The technique, designed originally for use in methods classes, involves the following steps: (1) Set up a calendar scheduling the dates on which each trainee will take the role of "teacher". Two trainees are given the same role-playing situation. (2) Provide each "teacher" with a statement of the

teaching objective and the situation a few days before the simulation (until the trainees have learned to prepare their own). (3) At the time of the simulations send the two "teachers" out of the room and orally assign roles to several students. (4) Have one "teacher" carry out the simulation while the other waits outside the room. (5) As director, review certain observational cues before opening the discussion and then ask the "teacher" how he felt in the situation, how he interpreted the situation (what the students were trying to do in their roles), and whether he accomplished what he set out to do in terms of the teaching objective. Then ask the students how they felt in the situation and whether their needs and concerns were dealt with adequately. (6) Call the second "teacher" into the room (the first may remain) and repeat the simulation and the discussion following the simulation. (7) Finally, discuss variations in the ways the two "teachers" handled the situations, being careful to keep the discussion in the here-and-now and sensitive to feelings.

Here is a sample situation.

General teaching objective: to develop the students' abilities to understand and use the processes of science to acquire new knowledge.

Teaching situation: a laboratory setting, where a discussion of how to design an experiment is to take place.

Class role: An average class in the middle of the second semester. Each student is to design and carry out a simple experiment, after this discussion.

Student Role A: Confused; "Why don't you just give us a printed exercise?"

Student Role B: The grade grubber; "How are you going to grade these experiments? Isn't everybody going to be doing something different?"

Student Role C: The "why" kid; Has the notion that the methods of science require asking why, but the "whys" he comes up with are trivial and disrupting. Why use a beaker instead of a flask? Why are the numbers on the thermometer in red?

Observational cues for the director: Is the teacher patient in clarifying questions? Are "student" questions accepted, but limited where necessary? How does the "teacher" express his own feelings? Is the objective accomplished; that is, are the students prepared to design their own experiments?

The above situation might be useful for a group of teachers (at any level) to help them tune in to some of the problems of teaching experimental design. Those who are playing the roles of "students" may create their own roles from their rich experience of problems actually encountered.

Lehman suggests a number of non-classroom applications of the technique. Simulations that take place in the classroom could help prepare teachers for conferences with students or with the department chairman, and at the secondary level, with parents and principals. Simulations could also be used to prepare for job interviews, oral examinations, or any other situation in which a simulation is virtually the only way to gain experience before the actual event.

The most complex simulation to come to my attention is Enviro County, a gaming simulation of regional planning process. Five problems are carefully laid out in a fictitious setting and the roles for a fifteen member planning commission are specified. The project was supported by the National Science Foundation and developed at the Oak Ridge National Laboratory. (The report of the project is available for $2.00 from the Superintendent, Oak Ridge Schools, P. O. Box 0, Oak Ridge, Tenn.)

Computer technology has contributed to the complexity of simulations that are possible. Using the Environmental Protection Agency's computer simulation, CLEANAIR, one course participant, Edward Brandt, North Carolian Wesleyan College, Rocky Mount, N. C., developed a laboratory activity in which students

"participate in pollution control decisions, using the computer for immediate feedback on the success of the strategy, detect shortcomings of the computer based model, and expand [their] appreciation of the complexity of problems involved in providing clean air."

Games

Games that can be used in science teaching, according to Carlock (1972), have four factors in common: (1) they represent a real thing, (2) they simplify by omitting some aspects, (3) they make critical factors prominent, and (4) they facilitate analysis by concentration on specific aspects of the critical factors. Carlock goes on to suggest two attributes of games that counteract defects on our traditional educational system. First, simulation games allow students to experience, at least in simulation, some of the kinds of situations they might really experience in the future. The simulated experience creates a need to know, thereby increasing the motivation to learn. Second, participation in games provides students with opportunities for success. The academic pursuit of science often proceeds with little opportunity for reward for the students. Games offer opportunities to use information and problem solving skills to achieve success.

The following bibliography of environmental games is reprinted with the permission of the author:

BIBLIOGRAPHY OF ENVIRONMENTAL GAMES
FEBRUARY 1974

J. DAVID KELLER
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THE UNIVERSITY OF AKRON
AKRON, OHIO 44325

Balance

A classroom simulation for about seventh grade through adult. The unit is designed to take about 3 weeks although teachers can modify it. A three hour version is included for clubs and civic groups. Students play the role of various people in the community making decisions on environmental concerns. Booklet can be reproduced in classroom quantities. $10.00, Interact Company, Box 262, Lakeside, California 92040

Baldicer

A simulation game dealing with food production and distribution. Each player is a food coordinator responsible for survival of 150 million people. The catch to the game is that a few of the players start the game with extra "baldicers." $25.00, John Knox Press, Box 1176, Richmond, Va. 23209

Clean Water

Deals with problems of industrial waste, nuclear power plants and pollution from upstream similar in design to Dirty Water. $6.00, Damon Educational Division, 80 Wilson Way, Westwood, Mass. 02092

The Dead River

A simulation game of river restoration designed for 10 to 30 players at the Junior-Senior High and adult level. Presents a real water pollution problem and gives each participant a role to play in problem solving. Can be played in sequential lessons. $7.00, Union Printing Company, 17 West Washington Street, Athens, Ohio 45701

Dirty Water

Each of the 2-4 players is the water pollution commissioner of an industry surrounded lake. The first person to stock his lake with a balance of organisms wins. Ages 8-adult. $7.00, Damon Educational Division, 80 Wilson Way, Westwood, Mass. 02090

Ecology: The Game of Man and Nature

The game involves players achieving a balance between man's activities and the natural environment while traveling through the four stages of development; hunting, agriculture, industrial and environmental. $7.00, Damon Educational Division, 80 Wilson Way, Westwood, Mass. 02090

Ecopolis

This is a classroom simulation for 4th through 6th grades. The simulation takes 3 weeks to complete. The classroom desks are moved to the perimeter of the room and a community is drawn on the floor with colored chalk. Students make decisions and debate the effects of their decisions. Booklet can be reproduced in classroom quantities. $10.00, Interact Company, Box 262, Lakeside, California 92040

Energy - Environment Game

Includes filmstrip, cassette tape, teachers guide, players manual and 32 role profiles. Edison Electric Institution, 90 Park Avenue, New York 10016

Expiration

An agricultural finance game studying ecology. $5.95, Schultz Games, Route 2, Brookings, South Dakota 57006

Extinction

2-4 players populate the island of Darwinia. Their genetic code is determined by their draw from 6 decks of cards in the gene bank. They must follow the natural processes of life. The objective is to keep from becoming extinct. Age 12-adult. $11.95, Sinauer Associates Inc., 20 Second Street, Stamford, Connecticut 06905

Game of Sacrifice

Sacrifice is an environmental conflict game that divides the class into interest groups in the community. Groups make decisions on air pollution and other community problems. 4th grade through junior high. $4.95, Education Ventures, Inc., 209 Court Street, Middletown, Connecticut 06457

The Garbage Game

This is a jigsaw puzzle ecology game. Students earn ecology points by putting puzzle pieces together into ecology cartoons. In the process they are governed by ecology principles. $7.00, Education Ventures Inc., 209 Court Street, Middletown, Connecticut 06457

The Homestead Game

An ecology game designed for 2 to 6 players. $5.95, Schultz Games, Route 2, Brookings, South Dakota 57006

Land Use

The game brings out the conflict between the desire to have quality housing and the desire to have natural resources. In developing land, participants discover concepts of cluster zoning, planned unit development, etc. $1.95, Education Ventures, 209 Court Street, Middletown, Connecticut 06457

Litterbug

A game for the very young (4-10 years). Players move around the board collecting litter in a tiny trash can. $5.00, Damon Educational Division, 80 Wilson Way, Westwood, Mass. 02090

Man in His Environment

Not a game in that there is no specific point of completion, but instead two separate activities requiring the students to role play. Designed for classes from 3rd through 6th grade. Time required ranges from 20 minutes to several days. Free to educators only from local Coca-Cola Bottling Company. Ecology Kit Code X01[illegible].

New Highway

Interest groups debate alternatives to the construction of a new highway. Each interest group sees the situation through a different point of view. 4th grade through junior high. $4.95, Education Ventures, Inc., 209 Court Street, Middletown, Conn. 06457

Planet Management Game

A computer designed simulation of existing conditions on the planet earth. Players make decisions to improve the population, income, food, and environment. Considered the one that most accurately simulates existing conditions of earth. Designed for five although even one can play as easily as a whole class. List Price $16.00; School Price $12.00, Houghton Mifflin Company, 110 Tremont Street, Department M, Boston, Mass. 02107

The Pollution Game

An environmental Monopoly game. Players of one board quickly learn to play as a team rather than compete. This game is designed to be played by simultaneously competing teams of players, although it works for only one board. List Price $12.00; School Price $9.00, Houghton Mifflin Company, 110 Tremont Street, Department M, Boston, Mass. 02107

Population

In Population, each of the 2-6 players must try to take his undeveloped country and develop it into an advanced industrial nation whose population and resources are in balance. Age 12-adult. $7.00, Damon Educational Division, 80 Wilson Way, Westwood, Mass. 02090

The Redwood Controversy

Players act as legislatures, experts, and pressure groups. The game is based on a real situation arising on California coastal redwoods. 21 students are given specific roles. Others are senators. 30 can play. List Price $10.00; School Price $7.50, Houghton Mifflin Company, Department M, 110 Tremont Street, Boston, Mass. 02107

Smog

Each player assumes the role of an elected official in his town and is responsible for managing the quality of the air. He confronts the problems of air pollution as he moves along a "decision tree". 14-adult. $7.00, Damon Education Division, 80 Wilson Way, Westwood, Mass. 02090

The World Puzzle

The World Puzzle is a 2' by 3' map of the various landforms in the world. Not designed as a specific game but a series of activities that the teacher can modify for specific uses. $12.95, Education Ventures, Inc., 209 Court Street, Middletown, Conn. 06457

Of particular interest to behavioral scientists are the Psychology Today Games: Blacks and Whites, Cities, Body Talk, Man and Woman, and perhaps others that have been developed recently. These games are produced by Communications/ Research Machines, Inc., Del Mar, Calif. Most of these games encourage each player to increase his sensitivities to the situation being experienced by the other players; some of the games require cooperation among the players, such

that nobody wins unless everybody wins.

Games with Ulterior Motives

First popularized by Berne (1964) and developed by Harris (1967), transactional analysis has contributed to the understanding of human interactions, including non-productive interactions--games with ulterior motives. Ernst (1972) has applied the technique to classroom interactions. The basic concepts of transactional analysis applied to the classroom are: (1) that each individual's personality includes components of Parent, Child, and Adult, (2) that the most productive classroom interactions are Adult to Adult, and (3) that a teacher can foster such interactions. To do so, he must learn to recognize the Parent, Child, and Adult in himself and his students. He must also develop ways for his Adult to monitor his own transactions, and ways to encourage students to use their Adult to monitor their transactions.

Child can be expressed as creativity, playfulness, and curiosity, the parts that should be encouraged; Child can also be expressed as impatience, pouting, anger. Parent can be legitimately nurturing and protective; sometimes it becomes over-protective. Parent can also be expressed as statements or actions based on prejudices and rules accepted uncritically, unnecessary do's and don't's. The Adult receives information, stores and uses that information to make logical decisions, but the Adult has no feelings or emotions. The most productive interactions are those in which the Adult is monitoring open, honest transactions without unduly limiting feeling or creativity. The non-productive, disruptive transactions--the games with ulterior motives--are to be avoided.

A single example adapted from Ernst (1972) of complementary games in which

student and teacher reinforce each other's game playing will illustrate the basic ideas of transactional analysis. The student might be playing "Here I am, Teacher, teach me." The Child is going to win by not learning anything. The teacher responds with "Here is the way I want you to do it." (parent) Student: "I'm not learning anything in your class." (child to parent) At this point the teacher can shrug his shoulders, "Look how hard I have tried." (parent) or he can ask of the student, "What are you planning to do about it?" (adult) The whole game could have been avoided by the teacher structuring the learning situation so that the students had to take responsibility for their own learning.

Ernst concludes that most teacher-student games are of the "parent-child" variety and that teachers can improve the learning situation by recognizing Parent voices and Child voices. After recommending contracts as a way of being specific about what students are to accomplish, he concludes his book with the following:

> . . . The important thing is recognizing that something is going on besides the obvious transaction. Then you know there is an ulterior motive and this a game. The Parent, Adult, and Child ego states are all O. K., and all necessary, and the games are not in themselves bad and crooked. It is the payoff that determines what the game player is angling you to do. To avoid unpleasant games you can simply decline the opening move.

The Role of the Teacher

In the context of the previous section, one aspect of the role of the teacher in directing simulated situations is to be alert to the possibility of games with ulterior motives. Keeping the situation focused on a problem to be solved and placing the responsibility for learning with the students not only

tends to avoid unintended games, it also encourages the positive aspects of simulations: insightful learning, application of scientific concepts, the development of problem-solving capabilities, and the improvement of skills in communication and interpersonal relationships. The simulation is one of the teaching alternatives in which it is easiest for a teacher to become a co-learner and to implement other qualities of a facilitator. (Refer again to Rogers' qualities of a facilitator.) If a learning situation built on mutual trust can be created prior to the use of simulated situations, it is likely that the students will feel free to enter into their roles. Lehman (1971) stresses that "the most important requirement for any role-playing program is that the participants come of their own free choosing, not being required or coerced to participate."

Problems of Implementation

Most of the problems I have encountered result either from our tendency to think of a "game" as a frivolous or fun-seeking activity, or to think of learning situations as being limited to lectures and laboratory exercises. An effort to view simulations and games as serious learning experiences will go a long way toward avoiding problems of implementation.

Space and time pose no real problem because the typical classroom or lecture hall can be used effectively and a simulation can be carried out during a regularly scheduled class period. Commercially available games may be used most effectively in laboratory settings where tables, small groups, and larger blocks of time are customary.

How to Evaluate Simulations

Most of the sample simulated situations include some questions to be used in critiquing the simulation. The games each have their own rules and their effectiveness can be measured in part by the significance of the problems they present. Three general principles for interpreting situations are offered by Lehman (1971). In somewhat generalized form, they are: (1) Did the participants achieve the specific objectives of the situation, including (a) the learning of science and (b) the development of skills in communication and interpersonal relationships? (2) Were the role-players (or game players) able to get some personal satisfaction out of the experience (an insight of some kind or other feeling of success)? (3) Were the techniques used scientifically, socially, and professionally acceptable?

Research on the Use of Simulations

Much of the "evidence" for the effectiveness of simulations as a teaching strategy is based on the subjective judgments of the users of simulations. Several researchable hypotheses can be suggested (stated as null hypotheses): There is no significant difference in the problem solving skills of students who have participated in simulations and those who have not. There is no significant difference in the capacity for insightful learning of students who have participated in simulations and those who have not. Similar hypotheses could be stated for communications skills, interpersonal relationship skills, and ability to perceive complex relationships. The major problem is measuring these skills and attributes accurately and reliably. Resources which are available in the form of printed tests for some of these skills and attributes are described in Buros (1972). Also, it

would be useful, if you have not already done so, to review the section on research in Science Teaching in Unit 1.

Self-Assessment

A-1. Define: simulation, role, playing, role-playing, game, (1)

A-2. Describe how the simulation techniques are related to learning theory. (2)

A-3. Describe your experiences in using role-playing situations and in using games. (3)

A-4. List the qualities of a teacher that you believe increase the effectiveness of a simulation. (4)

A-5. Describe the problems you encountered using simulations and games and how you dealt with them. (5)

A-6. Using the questions provided with the simulations, evaluate the effectiveness of the situations you have used. (6)

A-7. Use the list of criteria adapted from Lehman to evaluate the effectiveness of at least one situation. (6)

A-8. Design a research project to study the learning effects of simulations. (7)

A-9. Carry out the experiment you designed. (8)

B-1. Criticize the definitions provided in the study guide. (1)

B-2. State your own position with respect to simulations and learning theory. (2)

B-3. Create (or have your students create) and use a game or simulation. (3)

B-4. Critically evaluate the qualities of a teacher in terms of their effect on the quality of a simulation as a learning experience. (4)

B-5. Prepare an additional few paragraphs to be inserted in the section of the study guide on problems of implementation. (5)

B-6. Suggest some improvements in the criteria for evaluating simulations and games. (6)

B-7. Criticize the design of your experiment. (7)

B-8. Design another experiment. (7)

B-9. Criticize the methods used to carry out your experiment. (8)

B-10. Criticize your interpretation of your results. (8)

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UNIT 8

VALUES CLARIFICATION IN SCIENCE TEACHING

> Values are sometimes considered to be unchangeable because they are believed to be built into man's innate moral nature. In practice, however, many of the values by which men operate are based on prevailing social attitudes, as well as on inclinations, prejudices, and the common sense derived from the experience of daily life. There is also a real possibility that, in the future, values might increasingly originate from the natural and social sciences. Scientific knowledge per se cannot define or impose values to govern behavior, but it provides facts on the basis of which choices can be made.
>
> While choice can be made more rational by basing it on factual information, and on evaluation of consequences, it always retains a personal component because it must ultimately involve a value judgment. This constitutes another expression of the determinism-freedom polarity, which is one of the most characteristic aspects of the human condition.
>
> Dubos, So Human an Animal, p. 145

Purpose and Objectives

Given the persuasion of many scientists, including myself, that the process and methodologies of science are not concerned with values, it is important to say what this unit is not. It is not an attempt to tell you what your values should be, nor is it intended to encourage you to indoctrinate your students. But the practice of science leads to the development of products and the creation of situations about which decisions must be made. Society is legitimately and appropriately concerned with the value judgments that must be made about how the knowledge and capabilities derived from science and technology are to be used. This unit is included in the study guide because I have made a value judgment--

that science teachers have a responsibility to assist their students in learning to make value judgments and in clarifying their values about the use of science.

Upon completing the unit, you should be able to: (1) describe the valuing process, (2) explain its relationship to learning theories, (3) apply it in your teaching, (4) explain your role as teacher in values clarification activities, (5) describe some problems with implementing some of the activities and how you handled them, (6) evaluate the effectiveness of this teaching strategy, (7) propose some research questions related to valuing and (8) describe how you would design a research project to study one of the questions.

The Valuing Process

According to Raths, et al. (1966), there is a great diversity among people in the clarity of their relationship to society. At one extreme are the people who seem to know what they have to give and what they want to get out of life and go about living their lives with enthusiasm, purpose, and pride. They may, of course, see things about society that they feel need changing, but they go about fostering change in positive and constructive ways. At the other extreme are the people who seem not to know what they want or what they can contribute. They exhibit apathy, uncertainty, inconsistency, and perhaps extreme conformity or extreme non-conformity. The former have clearly defined values and the latter suffer from a confusion of values.

While these same authors do offer a brief definition of a value, "that which represents something important in human existence", they are concerned primarily with the process of how people arrive at and clarify the values they hold. Because young people are confronted with many more choices than were available to previous generations, and are generally given little opportunity to learn to

make choices by their parents and teachers, the authors have attempted to develop methods to help young people learn to deal with the complexities of modern living.

The valuing process involves consideration of the following criteria. For something to be a value, all seven criteria must be met.

1. Choosing freely--Values must be chosen by the individual to be really valued.
2. Choosing from among alternatives--Alternatives must be available to make a free choice.
3. Choosing after thoughtful consideration of the consequences of each alternative--Careful and intelligent weighing of consequences must replace impulsiveness if true values are to emerge.
4. Prizing and cherishing--Choices result in values we are pleased to hold.
5. Affirming--Willingness to publicly affirm values results from having made conscious choices that we prize.
6. Acting upon choices--Our real values guide our actions; verbal affirmation is not enough to show that a value is real.
7. Repeating--Values tend to persist, to make a pattern in a life.

These criteria can be summarized in three processes: <u>choosing</u>, <u>prizing</u>, and <u>acting</u>. Value indicators have some but not all of the characteristics of a value. These include goals, attitudes, interests, feelings, beliefs, activities, problems. Note in your notebook your initial reaction to the valuing process.

Relationship to Learning Theory

The valuing process involves conscious choices and thoughtful consideration of alternatives, and thus takes place at the reflection level of learning. To the extent that the process involves action consistent with choices, autonomous development-type learning is involved. In contrast, Bigge (1971) describes

Skinner's view of values as reinforcers of operant conditioning. In Skinner's words, "People behave in ways which, as we say conform to ethical, governmental, or religious patterns because they are reinforced for doing so."

Skinner (1948) develops his view of the Utopian community in his novel, Walden Two, where even the goals and aspirations of the people were defined by behaviorists and the satisfaction of the people with these goals was reinforced by conditioning. In response to the question of individual freedom, Skinner (1953) says:

> The hypothesis that man is not free is essential to the application of scientific method to the study of human behavior. The free inner man who is held responsible for the behavior of the external biological organism is only a pre-scientific substitute for the kinds of causes which are discovered in the course of a scientific analysis. All these alternative causes lie outside the individual.

Rogers (1961) points to what he feels is a flaw in Skinner's hypothesis: There is always a subjective value choice which lies outside the scientific endeavor. This choice defines the purpose or value of the scientific endeavor and can never become part of the scientific endeavor. The decision of the behaviorists in Walden Two to make man productive and well-behaved illustrates Rogers' point.

Less concerned with learning theory, but of significance in this unit is Rogers' assertion that values can be the subject of science. This would seem to be inconsistent with the quote from Dubos and my introductory sentence. However, what Rogers means is that one can apply the methodologies of science to determine whether one thing is better than another, if "better" is subjectively defined in terms of some other value. Rogers' example is germane to our purposes here:

> Now if I wish to determine whether problem-solving activity is "better" than knowledge of the three R's, then scientific method can also study those two values, but only--and this is very important--only in terms of some other value which I have subjectively chosen. I may value college success. Then I can determine whether problem-solving ability or knowledge of the three R's is most closely associated with that value. . . . But the value or purpose which gives meaning to a particular scientific endeavor must always lie outside of that endeavor.

Since Rogers feels that man is not limited to producing a controlled state of happiness, he goes on to suggest some interesting alternative values: man as a process of becoming, and the individual as a self-actualizing process (the process by which individual creativity adapts to an ever changing world). The question then is: Can science inform us about how to achieve these goals?

How to Use Values Clarification

Because we are primarily concerned with strategies for teaching science, it is important that we focus the use of values clarification techniques on values pertaining to the uses of scientific achievements. It seems generally true that when science teachers develop courses for the non-major, they are quite willing to include topics with social and ethical implications; yet, when they develop courses for science majors, they are determined to make these courses "real" science or "hard" science. Is it not especially important for a science major (who will become a doer of science) to understand the implications of science? Take time to answer that question; it is not intended to be rhetorical. The most common answer seems to be that, of course, understanding implications is important for scientists but they will get it later. Non-majors are probably taking their only science course and they will not have another chance. Do you think that in the curricula in your institution that science majors eventually encounter courses that cause them to consider the value implications of science?

4-8-6 Values Clarification in Science Teaching

Regardless of whether a course is for majors or non-majors, there is a wealth of value related topics in most science courses. Simon, et al. (1972) lists the following areas in which confusion and conflict of values are common: politics, religion, work, leisure time, school, love, sex, family, material possessions, culture (art, music, literature), personal tastes (clothes, hair style, etc.), friends, money, aging, death, health, race, war-peace, and authority. For each of these areas, name at least one value laden issue which is related to your area of science. Think about some of the questions students have asked. You should have no difficulty generating a long list of issues; you will probably also notice that you have not always dealt with student questions in ways that facilitate the student's clarification of his own values. Maybe you will make your own value judgment that values clarification has no place in the science classroom. O. K., I affirm your right to make your own value judgments--and I affirm your students' rights to make theirs. Even if you are "turned-off" by the notion of values clarification in the science classroom, please go along with me to the extent of checking the value judgment you have just made against the seven criteria for a value:

1. Have you chosen your position freely--or have you been coerced by colleagues?
2. Have you considered alternatives (such as those proposed here)?
3. Have you given thoughtful consideration of the consequences of such alternative?
4. Are you pleased with your decision?
5. Would you (or, better yet, have you) publicly affirmed your decision?
6. Have you acted upon your decision?
7. Are your actions repetitive and consistent?

In learning to use values clarification, there are a number of procedures to be avoided. Because some of them are natural tendencies of adults, at least, in their dealings with younger persons, you should not be surprised if you realize that you have done some of them. These tendencies are called the "typical twelve" by Gordon (1970). They are paralleled amazingly well by the "Don't's" listed by Raths, et al. (1966), who also provided some "Do's" to facilitate the clarification of values. Here are the lists for your consideration:

Do's	Don't's	Typical Twelve
Encourage choices	Set examples or models	Order, direct, or command
Help to discover and examine alternatives	Persuade or convince	Warn, admonish, threaten
Help to weigh consequences of alternatives	Limit choices to our values	Exhort, moralize, preach
Encourage consideration of what one prizes or cherishes	Inspire by dramatic or emotional pleas	Advise, suggest, give solution
Provide opportunities for public affirmation of choices	Give rules and regulations intended to be unthinkingly accepted as right (reward and punishment/reinforcement)	Lecture, give logical argument
Encourage actions that are in accordance with choices	Present cultural or religious dogma as unquestioned wisdom --"Always done it this way"	Judge, criticize, blame
Help to examine repeated patterns in behavior	Appeal to conscience to arouse guilt feelings	Praise, agree*
		Ridicule, name-call
		Interpret, analyze, diagnose
		Reassure, sympathize, console, support*
		Probe, question, interrogate
		Distract, humor, divert, withdraw

The two items among the "typical twelve" that are marked with an asterisk require some comment. It is Gordon's thesis that these responses carry unintended messages--messages that even you, the sender, are not aware of. For example, praise which does not fit the receiver's self-image may be seen as an effort to manipulate. The passing of a positive judgment also implies the power to pass a

negative judgment on another occasion. Reassuring or consoling a person who is distraught is likely to give the impression that the consoler does not really understand the problem or that the consoler is making light of a grave situation. The Do's provide students the opportunity to develop their own ability to make carefully considered choices which they personally prize and act upon. The Don't's and the "Typical Twelve", while nearly always done with the best of intentions, tend to remove choice, impose decisions, define what the student should prize in accordance with what we prize, accept responsibility for students' actions instead of giving student the opportunity to think through and accept responsibility for his or her own actions. (If there are situations in which there are no choices, then the valuing process need not and cannot be applied.) Because you may be left in a quandry as to what to do if the "typical twelve" and the "don't's" are to be avoided, some comments on the technique of active listening are in order. (My own experience with active listening, when I remember to do it and can manage to avoid making value judgments, is that it does, in fact, help students to work through the valuing process.)

Active listening, as described by Gordon (1970), involves decoding the messages sent by the student by trying "to understand what the sender is feeling or what his message means." Then he (the receiver) puts that understanding into his own words and feeds it back for the sender's verification. The receiver <u>does not</u> send a message of his own--such as an evaluation, opinion, advice, logic, analysis, or question. He feeds back <u>only what he feels the sender's message meant</u>--nothing more, nothing less.

As a teacher of science who presumably has a more thorough understanding of the value implications of the science you are teaching, you might well ask when and where do you send <u>your</u> messages (to use Gordon's lingo). If my interpretation

of Gordon is correct, and if his method applies to values clarification, you send your messages when the discussion concerns something that is a problem to you. For example, suppose you are engaged in a class discussion of population control. A student has been talking through his own views on the issue of having only two children. He had at one time thought he wanted a big family, and now he isn't so sure.

Student: On this business of population control, I used to think I wanted a lot of kids. Now that we have discussed the growth of human population, the scarcity of food worldwide, and the limits of natural resources, I'm not sure I have a right to have more than two children.

Instructor: You are concerned about not taking more than your share of the world's resources. (active listening)

Student: Yes, and I'm also concerned about whether there will be resources left for my children to enjoy, or whether some natural means of population control will come into play.

Instructor: You mean such things as famines or disease or war.

Student: Yes, I'd hate to bring children into the world only to have them starve or be killed in a world war.

Instructor: I see what you mean. I, too, am concerned about the long term utilization of the world's resources. The matter of recycling of resources is a problem I feel our government, and the governments of many other countries, have not considered, thoroughly and carefully. I'm worried that we will be faced with problems that are not necessary, simply because resources that should be available will not have been recycled properly. (Instructor's message)

. . .

Note that the instructor had the opportunity to pose a new problem and he had the attention of the students. Had the instructor's first comment been a judgment of the student's desire for a large family, "You haven't any business even thinking about having more than two children!", for example, the students would have probably been engaged in a defense of large families as a human right.

In beginning to use values clarification with your students, you may find it helpful to make copies of the Do, Don't and Typical Twelve lists for your

students and spend a little class time discussing them. Students should certainly receive a list of the seven criteria for a value. All of the techniques discussed here can be used between two students; they do not have to be teacher-student interactions. An interesting discussion might be centered around whether the items in the list of criteria are, in themselves, value judgments. Is there a method of science that could be used to determine this?

There are a number of responses that are classified as clarifying responses--responses that lead to thinking about the values expressed. Note the similarity between the responses listed below and the technique of active listening. Even though the responses are given as questions, it is important to ask them in such a way that you do not put the other person on the defensive. Having to defend a statement just made is antithetical to considering alternatives. Consider how you would feel if some one else asked you the question you are about to ask. Here is a list of clarifying responses (adapted from Raths, et al., 1966): (Numbers in parentheses indicate the criterion that is being clarified.)

1. How do you feel about that? (2,3)
2. Have you considered any alternatives? (2,3)
3. Did you <u>have</u> to choose that or was it a free choice? (Use this question only after you have established an atmosphere in which students feel free to say what they think, not what they think you want them to think.) (1)
4. Have you done anything about that idea? (6)
5. What do you mean by _____?; can you define that word? (3)
6. Where would that idea lead? (2,3)
7. Are you saying that . . . (repeat the feeling you thought the student was expressing)? (3)
8. What do we have to assume for things to work out that way? (3)
9. Is what you say consistent with . . . (something else that has been said)? (3)
10. Do you have any reasons for (saying or doing) that? (If atmosphere is such that this question is not a threat) (3)
11. Would you do the same thing over again? (Keep the tone non-judgmental.) (7)

Lest we go overboard on values clarifying responses, it is important to keep in mind what kinds of statements need clarifying responses. In general, it is

appropriate to use a clarifying response when some one has expressed an attitude, aspiration, purpose, interest or activity. A direct request for information is not to be responded to with a clarifying response. Some key words are statements that begin with: "I believe . . ., I feel . . ., I'm for . . ., I'm against . . ., My dream is . . ., When I finish college, I'd like to . . ., If I had my choice, I'd . . ., I just like to . . .". It is appropriate to close this section with a direct quote from Raths, et al. (1966):

> Although when we deal with values, we emphasize the need for a non-judgmental approach, for acceptance, for the student to arrive at his own ideas on the basis of his own critical thinking and evaluation, we do not mean to suggest that the teacher must remain neutral. The teacher may take a clear position about a value-related issue--but the student must be encouraged to take his own position and to use his knowledge of the teacher's position only as interesting information, perhaps worth considering when he makes up his own mind. If, however, a teacher senses that students are not yet accustomed to critical thinking and taking independent positions, he might well conceal his beliefs and attitudes until they are weaned from this intellectual and moral dependence upon authority.

Sample Strategies

Both Raths, et al. (1966) and Simon, et al. (1972) offer a large number of strategies and techniques for helping students to clarify values. The earlier work is devoted to strategies designed mostly for younger students. The later work describes strategies for use with older students and adults.

Before I describe the strategies, I would like you to list the five things you most want your students to achieve--educational goals you think are important. After you have recorded this list in your notebook, read on.

A good strategy to use in the first meeting of a class, before they have gotten into the subject or have heard of the valuing process, is the "-Ing Name Tags" strategy (Simon, p. 174) Each student writes, in large letters on a

5" x 7" card, his first name and five words ending in -ing which tell about who he is: car driving, studying, fun loving, etc. Students and the instructor mill around and get acquainted. Note that the technique asks participants to think about what they value and want to publicly affirm about themselves. What would you put on your card if you had just asked your freshman class to fill out cards? Write the five words in your notebook. (Just in case you are interested, here's what I would have written: teaching, writing, music listening, traveling, swimming.)

Several strategies have autobiographical components. For example, you might distribute a questionnaire (Raths, et al., 1966) to the class. Students should know that your interest is in making the course interesting for them. Also, they should understand that they may omit any questions they do not wish to answer. Questions which might be included are:

1. What other schools have you attended? Tell me something about them.
2. Write a sentence about each member of your family. (or 5 -ing words)
3. What career possibilities have you considered?
4. How do you spend your free time? What have you done the last two vacations?
5. What are your favorite magazines? TV shows?
6. If you could change some part of your education, what would it be?
7. If you were a teacher, how would you teach your classes?
8. Do you have some good ideas about things which you might like to mention? What are they?

Other autobiographic approaches include: (1) The life line (Simon, p. 236)--a line drawn with year of birth and estimated year of death, with important events both good and bad marked on the line; (2) Writing your own obituary (Simon, p. 311) --in which you indicate those things you would want to have accomplished and be

remembered by; (3) What's in your wallet? (Simon, p. 329)--things we keep with us indicate something about what's important to us; (4) Clothes and values (Simon, p. 331)--each student makes a chart, analysing what he wants his clothing to say about him and what he thinks his clothing does say about him; (5) Baker's dozen (Simon, p. 383)--make a list of thirteen electrical appliances you personally use around your home and rate them according to how necessary they are to you; and (6) Brand names (Simon, p. 378)--a list of the brand names found in your home and three columns of information about each: who chose the brand, why it was chosen, and whether it was chosen freely after careful consideration of a number of alternatives. A scientist might interject here some criteria for choice (nutritional value, safety, efficacy for intended purpose, environmental effect, etc.)

Life styles reflect values. To determine the extent of commitment, choice, and action involved in life style, there are several possible strategies: (1) students might be asked to rate descriptions of life styles (Simon, p. 343); (2) find situations in which to experience other life styles (Simon, p. 267)--dress as near like the people you will be with and spend some time in a police prowl car, with a visiting nurse, in an inner-city nursery school, or live on the amount of money (per person) a welfare recipient gets; (3) participate in a role playing situation similar to those described in an earlier unit, except that about half way through the simulation each player will exchange roles with another player who has a role with contrasting values; and (4) plan what you would take with you on a survival mission or on a space voyage.

Most of the strategies considered so far have stressed determining what values are important, what one prizes and is willing to publicly affirm. The next group of strategies will emphasize the choosing process.

4-8-14 Values Clarification in Science Teaching

The value sheet (Raths, Ch. 6) and the reaction statement (Simon, p. 385) can be used orally or as a written assignment to encourage students to consider an issue. The issues can easily be tied to the subject matter of the course. A short statement on a value laden issue is presented to the students, with or without questions to stimulate their thinking. For example:

> The strongest witness is the vast population of the earth to which we are a burden and she scarcely can provide for our needs; as our demands grow greater, our complaints against nature's inadequacy are heard by all. The scourges of pestilence, famine, war, and earthquakes have come to be regarded as a blessing to overcrowded nations, since they serve to prune away the luxuriant growth of the human race.
>
> Tertullian, The Blessings of Catastrophes, 200 AD
> as quoted by Hardin, Population, Evolution and Birth Control

1. What does this statement imply about the value of human life?
2. How does the statement compare with today's understanding of the factors that control population size in natural ecosystems?
3. What alternatives to catastrophes are there to control human population?
4. Which alternative would you choose and why?
5. How do your actions reflect your values?

Some additional statements on population which might be distributed for reaction are given below. Questions could be added to each of them.

> Be fruitful, and multiply, and replenish the earth, and subdue it; and have dominion over . . . every living thing that moveth upon the earth.
>
> Genesis 1:28

> On the eve of his 95th birthday, John Miller died leaving 5 of his 7 children, 61 grandchildren, 338 great-grandchildren.
>
> Everett - One Man's Family, 1961

> Darwin's theory of survival of the fittest seems to prove that the best thing to do was to let these people die out. "Why reduce mortality? You only further overcrowd an already overcrowded planet." That argument has been used with me but I think that we can feed and clothe and house as large a population as is likely to come in the next fifty or hundred years, and that is as far as we can see.
>
> Sir John Boyd Orr - Nothing to Worry About, 1948

> According to Malthus, vice and misery impose the ultimate natural limit on the growth of populations. To test this, I confined a population of wild Norway rats under conditions that only the animals' behavior toward one another might affect their increase in numbers. After 27 months the population stabilized at 150 adults instead of the 5000 expected. Stress from social interaction led to such disruption of maternal behavior that few young survived.
>
> Calhoun - Population Density and Social Pathology, 1962

The above statements were excerpted from Harden, Population, Evolution and Birth Control.

> A general answer to the question, "What needs to be done?" is simple. We must rapidly bring the world population under control, reducing the growth rate to zero or making it go negative. A federal Department of Population and Environment should be set up with the power to take whatever steps are necessary to establish a reasonable population size in U. S. and to put an end to the steady deterioration of our environment. Functions: promote intensive research on birth control, legislation guaranteeing right to abortion or sterilization, sex education in schools which includes discussion of regulating birth rate and techniques of birth control. As Hardin has pointed out equating a zygote with a human being is like equating a set of blueprints with a building. Our entire economy is geared to growing population and monumental waste. (Along with rapid population growth, there is increase in the quantity of goods used by each person.) Up goes the Gross National Product . . . as gross a product as one could wish for!
>
> Ehrlich - The Population Bomb, 1968

The reading anonymously of some of the reactions to a class might stimulate further thought on the part of the students.

There is no shortage of topics or statements about them. The following came from the front section of The Washington Post, Thursday, July 11, 1974, a randomly selected date.

> Heavy drinkers run a far greater risk of getting certain kinds of cancer--especially cancers of the mouth and throat region, the esophagus and liver--than non-drinkers, the government reported yesterday. . . .
>
> The House yesterday passed by a vote of 160 to 43 a bill to extend until Aug. 1, 1987, the law limiting damages that could be paid in case of an accident in a nuclear power plant. The law which sets $560 million as the limit of liability, doesn't expire until 1977, but proponents of the bill argued that the nuclear power industry needed to be reassured that the damage limit would be extended to avoid unwarranted disruption in planning new plants. Opponents of the bill, backed by environmental groups, argued that the rush to extend the act was unnecessary because it doesn't expire for three more years, and urged the House to wait for a new $2 million Atomic Energy Commission study on the probable consequences of a nuclear accident, to be completed in a month or so. . . .
>
> The Senate Tuesday voted unanimously to give Congress veto power over President Nixon's promise to provide Egypt and Israel with nuclear reactors. . . .
>
> The National Transportation Safety Board said yesterday it is investigating the failure of an engine cowling on a National Airlines DC-10 Monday that knocked out one engine and forced the damaged plane to make a premature landing. . . .
>
> The first complaint under a new state (Calif.) law prohibiting job discrimination against the handicapped was filed by a stuttering truck driver. The driver complained he was turned down for a job only because of his stutter, which does not impair his ability to drive a truck. . . .

The value survey (Simon, p. 112) helps students identify priorities in their own value system. The student is given a list (in alphabetical order) of values which are to be placed in rank order from the most to the least important. To illustrate the technique and to give some thought to our own priorities with respect to educational goals, here is a list of educational goals for you to rank. The list is adapted from Rubinstein (1974).

____achieve general education/broad outlook

____appreciate culture and beauty

____demonstrate concern for society

____develop communication skills

____develop desire to learn now and future

____develop self-awareness

____develop self-confidence

____develop social awareness

____improve creative abilities

____learn how to examine and use information

____learn how to get along with others

____learn how to use leisure

____prepare for or stay current in career

____understand changes that are taking place in the world

It would be interesting for instructors and students to independently rank order these educational goals. It is also worth giving some thought to the reasons for the order chosen.

The value continuum (Raths, p. 130 and Simon, p. 116) serves to help students realize that none of the issues are either-or, clear cut choices and that there are many positions along a continuum. For example, here are some continua to consider:

How do you feel about individualized instruction?

All instruction should be individualized. .. .. .. No instruction should be individualized.

With reference to the Washington Post article on damages from nuclear reactors, how do you feel about the decision?

Nuclear power industry should have the guarantee of a limit on damages. .. Environmentalists should have been able to forestall the decision until the study became available.

Other continua can be constructed from the quotations or the news items or from situations that you present in value sheets or reaction statements. Some problems that may arise are that students (and adults)often seek safety in a

middle-of-the-road position and that students may be particularly sensitive to what position the teacher might take. Another complicating factor is that some issues are multi-dimensional, that is, there are several continua related to one issue: distribution of power to make decisions, environmental implications, alternate energy sources, cost-benefit considerations. Each dimension could be used as an additional continuum on the nuclear damage issue. From my limited experience in attempting to develop continua, it is important to consider only one continuum at a time. After positions have been taken on the first continuum (the one illustrated for nuclear damage), one of the others might be considered:

How do you feel about alternate sources of energy?

No action should be taken to create new sources of energy. .. .. Every possible incentive should be provided to industry to create new sources of energy.

The third major component of the valuing process is acting on choices, consistently and repeatedly. To begin this process, review choices made in each of the strategies you have used. Appropriate questions include: Have you acted on your choice? What have you done to demonstrate your beliefs? Are all of the things you have done consistent with what you believe? Have you acted several times (or in several different situations) in ways that are always consistent with your beliefs?

The strategy of self contracts (Simon, p. 319) encourages participants to develop a method for getting at doing something they say they want to accomplish. Select one of the strategies involving rank ordering goals. From the rank order strategies, goals at the top of the list, choose one for action. Write a contract with yourself to meet that goal. Have your students write contracts with themselves. One precaution is that contracts should be realistic, not too grandiose as to be overwhelming. A small step toward accomplishing something

worthwhile to the individual making the contract is better (according to my values) than an unfulfilled contract. A final strategy combines all of the criteria for a value. The values grid strategy (Simon, p. 35) is useful in determining the extent to which our professed values meet all seven of the criteria for a value. Participants (including teachers) prepare a value grid, with seven columns, one for each of the criteria. There is also a column for a short phrase describing the issues.

ISSUE	1	2	3	4	5	6	7	
1.								
2.								
3.								
etc.								

The participant summarizes his position on the issue. Then he makes a checkmark in each column for which he can answer yes to the question related to that column:

1. Are you proud of your position?
2. Have you publicly affirmed your position?
3. Have you chosen your position from alternatives?
4. Have you chosen your position after thoughtful consideration of the pros and cons and consequences?
5. Have you chosen your position freely?
6. Have you acted on or done anything about your beliefs?
7. Have you acted with repetition, pattern or consistency on this issue?

We have by no means exhausted all of the strategies for values clarification. Many others are suggested in the Raths and Simon references. Also there are many variations which you and your students can create from the basic ideas presented here.

As a final exercise, make a list of the five most important educational

goals you have for yourself. Do not look at the list which you assigned rank order priorities to. Make an independent list. Then check it against those priorities to get an idea of the consistency of your values and to notice whether there are things you value that were not on that list. Finally, compare the list for your own educational goals with the one you prepared at the beginning of this section for the goals you would want your students to achieve. Are they different? Why?

The Role of the Teacher

Efforts toward values clarification should encourage students to become more adept at raising questions and considering alternatives, more capable of self-direction, and perhaps, even more positive in their attitude toward learning. The role of the teacher is to facilitate the development of these capabilities. The qualities of a facilitator of learning delineated by Rogers are essentially the same qualities needed by a teacher to facilitate the values clarification process. Refer to page 4-1-6 and reconsider these qualities. It is likely that, as you have worked through these units, the qualities of a facilitator are becoming more familiar. How many of the qualities do you now display in your teaching? Jot down some notes on your feelings about a facilitator. If you made notes on unit 1, you may want to compare what you wrote then with what you have just finished writing. Have your values changed? Have you consciously applied the valuing process to the qualities of a facilitator? If you have carefully considered alternatives and freely chosen your position with respect to facilitating learning, great! If your actions consistently reflect your beliefs, greater yet! If you know what conditions helped you to come to such clarified values, a list of those conditions would

be most helpful to other teachers and students. Please try to make such a list.

Another matter pertaining to the role of the teacher is maintaining emphasis on the things that are worth clarifying. Simon, et al., (1972) lists the following criteria to judge whether issues are worthy of values clarification. Issues worth clarifying should be of concern to the individual; involve a variety of alternatives; have significance for many lives; affect large areas of life (careers, not clothes, for example); be open to control (wars, not earthquakes); be related to other issues; and be a recurrent (not transient) issue. A possible problem with the use of these criteria is that large global problems meet the criteria but may be too large, or too abstract for individuals to feel that they can take significant action.

Problems of Implementation

If you share my view that values clarification is an important component of science education, perhaps the concern foremost in your mind is how you can legitimately work some of the strategies into the subject matter of your courses. One suggestion is to clip newspaper and journal articles that provide ties between subject matter and contemporary value-laden issues.

The classroom atmosphere is also an important consideration in the use of values clarification strategies. Since one of the criteria for a value is that it is freely chosen, an atmosphere of openness, honesty, acceptance, and respect is important. When the number of students in a class is large, it may be necessary to ask groups of three or four students seated next to each other to discuss some of the issues among themselves. Both teachers and students should develop the technique of active listening.

In situations where you, as the instructor, are the leader or a participant

in the activity, it is important that you avoid the "typical twelve". Use an open ended question; avoid asking questions that you already have an answer to. As you progress toward the open, trusting atmosphere you can feel more free to express your values. Also, it is consoling to feel that students are more likely to listen to what you have to say and weigh it carefully if they do not feel pressured to accept (or pretend to accept) your values.

It may be helpful to keep colleagues and administrators informed of what you are doing in a general way. Perhaps some other faculty members will be interested in conducting similar activities in their classes. Many of the value-laden issues are interdisciplinary in content, so there are advantages of teaming up with colleagues on values clarification strategies. A series of team-taught interdisciplinary sessions for students from several courses might replace the regular lectures for a period of time. You and your colleagues will be able to devise other approaches to cooperative efforts.

Evaluating Values Clarification Strategies

As you begin to prepare value sheets (or statements for reaction), it will be helpful to have some methods of evaluating them. Raths (p. 233) suggests some methods for judging the quality of the statement itself and a coding system for judging the quality of the questions. Rate the statements along these continua.

Topic:				
Likely to touch many students	..	Of some concern to some students	..	An intellectual exercise, far from the lives of students
Thinking:				
Stimulates reflective thinking	..	Could stimulate more thinking	..	Simple answers require no real mental exertion

Alternatives:		
Many provisions for alternatives to be considered ..	A narrow range of alternatives to be considered .	Student not involved in considering alternatives
Action:		
Behavior will be changed; lesson made a real difference ..	Somewhat lacking in consideration of consequences and actions ..	No change in behavior, makes little difference to the students
Penetration:		
Touches lives, painfully sometimes, but productively ..	Noticed but with no strong or lasting effect ..	Bland, superficial, calls for off-the-cuff response

Code the questions as follows:

Q-Question narrow-one right answer
Th-Should stimulate real thinking
Pr-Identifies a significant problem
M-Moralizing is implied
CT-Changes topics before main emphasis was developed
SW-May produce a "so-what?" reaction
E-Enough is enough-move on to another
Cr-Criticism is built in-write a more neutral question
V-C-Question will likely advance the values clarification process
A-Question calls for action
Int-Intellectual emphasis good but needs more emphasis on action

Take time now to rate the statement provided on page 4-8-14 from Tertullian. Also code the questions based on it. Point out weaknesses in the statement for use as a value sheet. Pose questions that overcome some of the shortcomings you find. Please make notes of these suggestions; they will be helpful in revising this study guide. Students may also be able to make significant contributions to the improvement of values clarification strategies by rating statements and coding questions.

In responding to students'efforts at answering questions on value sheets or other values clarification efforts, you may find use for the following codes (Raths, p. 247).

E-extremes (all, none) in comments; may need reconsideration

VJ-Value Judgment; do you want to be more objective?

AT-Attributing some feeling to a situation without clear evidence; state a basis

for your interpretation or omit it

G-Generalizations; more data may be needed to support conclusions

Alt-Alternatives; more careful consideration is needed

OS-Oversimplification; too great a simplification of complex situation

PR-Projection; appears that respondent may be putting his own feelings into the situation, consciously or unconsciously

D-Dogmatic; maybe a decision was made before all alternatives had been considered

These codes may be appropriate on a variety of reports as they seem to provide a way to point out flaws in thinking as well as shortcomings in applying the valuing process. Please code any parts of this study guide for my benefit. I am quite sure I have made some of these errors and I would certainly like to remove them during the revision.

Research on Values Clarification

Among the teaching alternatives presented in this study guide, research on the effects of value clarification strategies are possibly the most challenging. In the first place there is great need for better and more reliable methods of measuring values and changes in values. Several instruments have been developed to attempt to make such measurements, but none are completely satisfactory. Descriptions of the available instruments may be found in the Mental Measurements Yearbook by Buros (1972). Valuable research contributions can be made in this challenging area.

Another challenging research area is that of the valuing process. Starting from the definition of a value as something that penetrates a person's life, must all seven of the criteria described in this unit be satisfied for a thing to qualify as a value? Are these seven criteria sufficient to designate a value, or are there other criteria? Is it sufficient if the three components (prizing,

choosing, and acting) are represented in some way? Research designs, according to Raths et al. (1966), can be developed to test the effects of omitting one or more of the criteria. The development and testing of such research designs would be a worthwhile venture.

A third problem that might be considered is whether all people engage in the same process to arrive at their values. If not, what processes are used and what personal characteristics are related to each different process?

A fourth problem is the extent to which the content of values is independent of the atmosphere in which they are developed. Is it really necessary to have an accepting atmosphere for individuals to engage in the process of clarifying their own values?

Finally, does the valuing process require both cognitive and affective involvement? Most of the questions posed here were suggested by Raths, et al. (1966). What other problems have occurred to you? How would you design experiments to answer any of the above questions or questions you have thought of?

Self-Assessment

A-1. Describe the seven criteria in the valuing process. (1)

A-2. Explain how this process is related to learning theories. (2)

A-3. Describe at least one situation in which you have used the valuing process in your teaching.

A-4. Describe what your role has been in the values clarifying strategies you have used. (4)

A-5. Discuss some problems of implementation you have experienced, the degree of success and also the shortcomings you experienced. (5)

A-6. Using the continua and the codes suggested in this unit, evaluate the effectiveness of the strategies you have used (or are planning to use). (6)

A-7. Propose a researchable question pertaining to values and design an experiment to answer the question. (7,8)

B-1. Propose an alternative theory of valuing or criticize the one proposed here. (1)

B-2. Prepare a critique of the strategies you have applied and substantiate your critique with logical reasons. (3)

B-3. Discuss the pros and cons of Rogers' qualities of a facilitator and give examples from your experience. (Include your views on whether these qualities facilitate values clarification.) (4)

B-4. Propose some strategies to avoid the problems you have experienced in implementing values clarification activities. (5)

B-5. Develop some additional evaluation procedures for determining the effectiveness of teaching strategies. (6)

B-6. Carry out the experiment proposed in A-7. (7-8)

B-7. Criticize your own experiment. (7-8)

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Raths, L. E., M. Harmin, and S. B. Simon. 1966. Values and teaching. Charles E. Merrill, Columbus, Ohio. Written primarily for teachers at the secondary level, the ideas are well worth reading by any teacher.

Rogers, C. R. 1961. On becoming a person. Houghton Mifflin Company, Boston. Contains an interesting discussion of the emerging powers of the behavioral sciences, as seen by Rogers at the time of publication.

_____. 1969. Freedom to learn. Charles E. Merrill, Columbus, Ohio. The qualities of a facilitator of learning are the same qualities needed by a teacher who would encourage values clarification.

Rubinstein, M. F. 1974. Patterns in problem solving. Prentice-Hall, Inc., Englewood Cliffs, New Jersey. Written by another Chautauqua-type course director, it contains many excellent discussions of problem solving.

Simon, S. B., L. W. Howe, and H. Kirschenbaum. 1972. Values clarification. Hart Publishing Company, New York. A handbook of practical strategies for teachers and students.

Skinner, B. F. 1948. Walden two. Macmillan, New York. A novel about the behaviorist's utopia.

_____. 1953. Science and human behavior Macmillan, New York. A classic statement of behaviorist views about the nature of man.

Other Resources

Hastings Center Studies and Reports, Institute of Society, Ethics and the Life Sciences, 623 Warburton Avenue, Hastings-on-Hudson, N. Y.

The Adirondack Mountain Humanistic Education Center, Upper Jay, N. Y. Offers workshops for all ages on values clarification and other topics. Also maintains a collection of publications for sale.